Studyguide for Exam 2 Spring 2012

Chapter 7 Marine Animals Without a Backbone

Invertebrates

• Animals without a backbone are known as invertebrates. Those with a backbone are called vertebrates.
• About 97% of animals are invertebrates.
• All major animal groups have representatives in the marine community.
• Several animal groups are exclusively marine.
• Basic body structure:
  – Symmetry (body plan)
    • Radial- round; equal parts radiate out from a central point (like that seen in a sea star)
    • Bilateral- organism can be divided into right and left halves that are more or less equal (ex: marine mammals)
    • Sponges have no symmetry and are known as asymmetrical.

Major Phyla of Marine Invertebrates

• Sponges
• Cnidarians
• Flatworms
• Annelids
• Molluscs
• Arthropods
• Brachiopods
• Arrow worms
• Echinoderms
• Tunicates
• Lancelets

Which phyla are mainly marine? Which phyla are mainly in water? Which phyla have some success on land?

Burgess shale fossils

  Mudslide on the british Columbia continental shelf preserved soft bodied invertebrates from right after the Cambrian era
  • Many body plans are now extinct
  • Only one chordate fossil found
  • In theory if evolution was “replayed” we may not have the same organisms that exist today. What does this suggest about “the meaning of life?”

Choanoflagellates

  Can form colony
  • Have long been considered to be the common ancestor of multicellular animals
• Porifera: The Sponges – No symmetry
• Types of Cells:
  – Choanocytes (or collar cells) –
  – Very similar to free living choanoflagellates
  • Line interior canals of the body;
  • Flagella on the choanocytes create a water current that brings more food particles into the body
  • “Collars” on choanocytes traps food particles.

• Porifera: The Sponges
• Characteristics of Phylum:
  – All sponges are sessile (non-motile and living attached)
  – Numerous tiny pores exist in the body to allow water to pass through the sponge.
  – This water movement is required to allow sponges to filter feed (a type of suspension feeding) on plankton and dissolved organic matter in the water.
  – Sponges do not necessarily have any body symmetry. This is the only phylum that is not symmetric as a general rule
  – Asymmetric body with no true tissues or organs.
  – Mostly marine
  – Regeneration capability
  – Filter feeders

Glass sponge Hexactinella
Reef was found off the coast of Oregon at methane seeps

Cnidarians: Stinging animals Radial symmetry
• Characteristics of Phylum:
  – Radial symmetry
  – Mostly marine organisms
  – Two body forms exist:
    • Medusa – free floating form which is transported by water currents, mouth with surrounding tentacles are positioned downward
    • Polyp – sessile, attached form with mouth and tentacles are positioned upward
  – Cnidocytes (stinging cells) with nematocyst capsules located on tentacles. These are used for protection and for feeding

• Jellyfish lake Palau – non-stinging jellyfish with symbiotic algae
Upside down jellyfish Cassiopea – also relies on photosynthetic symbiotic algae

Anemones
  – Polyps
  A few genera form associations with “clownfish”

• Ctenophores – also known as comb jellies Radial symmetry
• Characteristics of Phylum:
  – All marine
- 8 rows of thick cilia that beat continuously
- Long sticky tentacles used to capture prey voracious predators
- Most species are planktonic
- May be the basal animal lineage – what does this suggest about “the meaning of life?”

All the phyla that follow are Bilateral

Bilateral symmetry often means that the animal has a distinct dorsal and ventral part of the body as well as a front and back (anterior and posterior)
Many bilateral animals are mobile and move in an anterior direction. Eventually this can be a good reason to have sensory organs in the anterior part of the body and to develop a concentration of nervous tissue in the head region

• Flatworms
  • Characteristics of Phylum:
  - One example: tapeworm
  - Some parasitic, others free-living
  - First brain- clusters of nervous tissue in head
  - Bilateral symmetry
  - Eye-spots present to determine light/dark patterns

• Molluscs
  • Characteristics of Phylum:
  - Name means "soft body"
  - Basic body plan – head, muscular foot and visceral mass in most species. How does this basic body plan result in the main types of mollusks: bivalves, gastropods, and cephalopods?
  - Mantle- secretes shell, waste disposal, sensory reception, respiration
  - Many have a shell of calcium carbonate
  - Radula for grazing is unique to this group
  - Well developed nervous system
  - Open circulatory system (usually), except in squids and octopuses which swim actively. These have a closed circulatory system

• Types of Molluscs:
  - Chitins
  - Clams, Oysters, Scallops, Mussels, etc.
    - Two shells or “valves”
    - Adductor muscles secure valves together
    - Muscular foot used for burrowing in bottom and other locomotion
    - Gills for respiration & food gathering (filter feeding)
  • Some have a specialized mantle tissue with symbiotic algae Tridacna clams

• Gastropods
  - Largest class of molluscs, can live on land
  - Coiled shell on most species
–No shell on sea slugs (nudibranchs)
–Radula for grazing on plants in most, some are deposit feeders

• Cephalopods
  – Squid, Octopus, Nautilus, & Cuttlefish
  – All marine
  – Fast swimming predators due to water jet propulsion
  – Can have a closed circulatory system
  – Most developed nervous system, Well developed eyes
  – Thick mantle covers the body
  – Use beak-like jaws and radula to crush or rip prey
  – Adapted tentacles

  *Vampyroteuthis infernalis*
  • Vampire squid from “hell”
  • No ink production, produces bioluminescent mucus cloud
  • Black surface
  • Lives in the oxygen minimum zone

• Annelids, Segmented Worms
• Characteristics of Phylum:
  • Live in salt water, freshwater or moist terrestrial
  • Well developed nervous system (with brain)
  • Segmented internally and externally
  • Closed circulatory system
  • Bilateral symmetry

• Types of Annelids:
• Polychaetes:
  – Largest group of annelids, also most diverse
  – Nearly exclusively marine, some in freshwater and brackish water
  – Distinct head
  – Some build calcareous tubes or tubes of sticky proteins
  – Some are carnivorous, others are deposit feeders

• Leeches
  – Most found in freshwater, some tropical species in moist terrestrial environment, few marine

• Oligochaetes:
  – Terrestrial earthworms are also in this group
  – Mainly found in shallow coastal waters

*Osedax*
Annelid worm that lives on decomposing whale bones
Has bacterial symbionts and invades the bone via “roots”
They have a bright red plume. The visible worms are all females.
The males are microscopic and live as parasites in the females
• Arthropods
  • Characteristics of Phylum:
    – About 1 million species known, mostly marine
    – Most marine species are in a group of arthropods called crustaceans
    – About 75% of all animals on earth are arthropods
    – Arthropods are very successful on land
    – Chitin exoskeleton- hard, but light and moderately flexible

• Types of Marine Arthropods:
  • Crustaceans
    – Gills for respiration
    – Head and thorax fused into a single unit called a cephalothorax
    – Large array of appendages specialized for different functions; ex: pinchers on crabs, swimmerettes on the underside of shrimp hold developing eggs, etc.
    – Types of crustaceans – copepods, barnacles, amphipods, isopods, crabs, shrimp, lobsters, etc.
  Ostracod
    • Shrimp-like but inside a bivalve “shell”
  Barnacles – Cirripedia
    • Sessile, have calcareous plates, and filter feed
  Isopods
    • Look like pillbugs, normally small
  Mantis shrimp - Stomatopods
    • Second leg is a spear or club, special hard chitin
  • Insects:
    – Very few marine insects exist

• Brachiopods
  • Characteristics of Phylum:
    – Two shells or “valves” enclose the body

• Arrow Worms
  • These are Deuterostomes
  • Characteristics of Phylum:
    – All marine
    – These organisms are planktonic, but slightly larger than most plankton
    – They are voracious predators that are widely distributed in the marine community
    – Grasping spines on head with venom like tetrodotoxin

• Echinoderms
  • These are Deuterostomes
  • Characteristics of Phylum:
    – Name means ”Spiny Skin”
–Radial symmetry in adults- larvae are bilaterally symmetrical
–Can regenerate lost body parts

Types of Echinoderms
• Sea cucumbers
• Sea Urchins
• Sea Stars

Invertebrate Chordates
• The Phylum Chordata is a phylum that contains two invertebrate groups, tunicates and lancelets, as well as many other, more familiar animals such as fish, amphibians, reptiles, birds and mammals.
• These are also Deuterostomes
• Chordates have several features that are seen at least during some portion of their life – Notochord, dorsal nerve cord, pharyngeal slits

• Tunicates – sea squirts, salps
  • Characteristics:
  • Often sessile function similarly to sponges i.e. they filterfeed

• Lancelets
• Characteristics:
  – Very small, only up to 3 inches long
  – Body shows segmented muscle tissue

Chapter 8
Marine Fishes

Classification of Fishes
Marine Fish
• Marine fish are vertebrates
• Some have vertebra made of cartilage, while others have bony vertebra
• Most fish are marine
• Fish are the oldest of vertebrates (found farther back in the fossil record)
• Fish are by far the largest group of vertebrates in terms of species and abundance
• About half of all vertebrate species are fish

Types of Marine Fish
– jawless fish
  • Hagfish
  • Lampreys
– cartilaginous fish
  • Sharks
  • Skates
  • Rays
  • Ratfish
– bony fish
  • Lobe-finned fishes
• Ray-finned fishes

Types of Marine Fish

hagfish

• Also called “slime eels” - they are not eels
• Copious slime may clog gills of predatory fishes
• Skin is used to make wallets and handbags

More Advanced Groups of Fish

• Cartilaginous and bony fishes are considered to be more advanced.

  • General Characteristics (advancements) seen in these Two groups:
    – Highly efficient gills
    – Scales cover the body
    – Paired fins
    – A wide variety of jaw and feeding types
    – Lateral line and other sensory organs
    – Streamlined body

Types of Marine Fish

• Cartilaginous

  • General Characteristics of Group:
    – Sharks, rays, skates and ratfishes are members of this group
    – Skeleton of cartilage (as the name implies)
    – Movable jaws with well-developed teeth
    – Placoid scales and paired fins
    – 5-7 gill slits open directly into the water in most species
    – Spiracles in many species (openings on head used to bring water directly in for respiration without opening the mouth)
    – Males in most species have projections of the anal fin called claspers that are used in copulation

Types of Marine Fish

• The Bony Fish

  – As the name implies, these fish have a skeleton composed of bone
  – More species than all other vertebrates combined
  – Gills used for respiration
  – Hinged jaws allow for a variety of different ways of feeding
  – Homocercal tail (two lobes of equal size) provides forward thrust
  – Flat bony scales protect body
  – Bony operculum covers the gills (provides better protection against injury compared to gill slits for each gill)
  – Swim bladder used for buoyancy control (some bottom dwelling fish lack swim bladder)
Variable body plans are adapted for specific environments

Atlantic bluefin tuna *Thunnus thynnus*
- Can grow >300 cm; 680 kg
- Extremely streamlined, one of the ocean’s fastest swimmers, endothermic
- 2001 440 pound tuna sold for $220,000 ($500/pound)

Bluefin tuna physiology
- Can have muscle temperatures approaching mammalian temperatures
- Muscle glycolytic and aerobic enzyme levels are among the highest on the planet
- Ram ventilation when swimming at high speeds

Goosefish or monkfish
- A type of angler fish
- Sit and wait predator
- Very small gill surface area
- Very low aerobic muscle, mainly sprint muscle

Tuna swimming
- Billfishes, tunas, some sharks
  - Head does not move side to side. Caudal fin acts like a “propeller”
  - Fins can be depressed into grooves and recesses.
  - Bulge of eye is streamlined with “adipose eyelids”

Generating lift
- In sharks, a swim bladder is absent (although there is a large lipid-rich liver to help in buoyancy) – therefore, sharks tend to sink when not in motion and there is no lift from the swim bladder while swimming either
- While swimming, sharks are aided by the “lift” provided by the pectoral fins

Billfishes
- Swordfishes also have heated brains and eyes
  - Specialized heating system warms brain and eye up to 10-15 degrees C above water temperature

Marine mammals
- Cetacea – whales, dolphins and porpoises
  - Order Cetacea
  - This order includes whales, dolphins and porpoises.
  - Fore limbs are modified into flippers.
• Fin-like tail is known as a fluke.
• Nostrils are located on the top of the head as a single or double opening known as a blowhole.
• Within the cetacea, two suborders exist, toothed whales (Odontocetes) and baleen whales (Mysticetes).
• Visually, the two suborders can be easily distinguished by the presence of teeth and a single blowhole (Odontocetes) or baleen and two blowholes.
• **SIZE:** In general, baleen whales are much larger than toothed whales, ranging in length from about 6.4-27 m (21-85 ft.). Most toothed whales are less than 6.1 m (20 ft.) long. **Baleen whales have rows of flexible, fibrous plates known as baleen that hang from the upper jaws (seen in diagram below).**
• Toothed whales are named for their simple, peg-like teeth, which vary considerably in number and size among the species.

**Order Cetacea**
• Toothed whales include dolphins, porpoises, belugas, narwhals, sperm whales, killer whales, river dolphins, and beaked whales.
• Depending on the species, toothed whales may be found in coastal waters, rivers or in the pelagic environment.

**Captive orca**
• 2010 large male, 22 foot 12000 pound kills trainer at seaworld.
• Involved in 1-2 other deaths
• Trainers were apparently not supposed to go into water with the orca
• Orca may have been “playing” with trainers ponytail
• This male is used for breeding purposes and has fathered about 15 calves at Seaworld

**Evolution of cetaceans**
• Closest living group: Hippos
• Were land animals that moved back to the water
• *Indohyus* - 4 legged ancestor of whales
• The 48 million year old ungulate *Indohyus* from India. *Indohyus* is a close relative of whales, and the structure of its bones and chemistry of its teeth indicate that it spent much time in water. In this reconstruction, it is seen diving in a stream
• Key similarities between whales and *Indohyus* in the skull and ear adapted for hearing underwater
• *Indohyus* was a plant eater
• Fossils of female *Maiacetus inuus* with near-term fetus in utero, as found in the field. The female's skull is shaded white (teeth brown), and other parts of her skeleton are shaded red. The single fetus, in birth position inside the mother whale, is shaded blue (teeth orange).
The fetus is positioned for head-first delivery, like land mammals but unlike modern whales, indicating that these whales still gave birth on land.

Why tail first?
- In a complicated birth, blowhole is last to emerge, preventing inhalation of seawater

Cetacean intelligence
- Large brain size
- Complex sound production
  - Extensively study but does not appear to be language

Behavior
- Which part of the brain (quality vs. quantity)
  - Brain neocortex (greatly developed in primates and humans)
  - spiny anteater (an egg laying mammal, related to the duck-billed platypus), neocortex (relatively much larger than that of a human).

Mirror self recognition
- humans and great apes show mirror self recognition, so do dolphins

Diving

Adaptations for Diving:
- Rapid breathing prior to dive -known as apneustic breathing
- Lungs remove 90% of O₂ from air (as opposed to 20% for humans)
- Elastic tissue in lungs helps them expand the lungs temporarily during apneustic breathing
- Marine mammals have more blood than non-diving mammals for their size (means more hemoglobin to carry oxygen)
- Muscles contain more myoglobin to hold oxygen in tissues
- The heart rate slows dramatically during a dive – known as bradycardia
- Blood flow is reduced to extremities and digestive system
- Muscles employ anaerobic respiration as necessary (results in lactic acid build-up)
- Marine mammals can tolerate more lactic acid than other mammals
- Rib cage and lungs collapse during dive to force air into tissues and prevent decompression sickness

Some animals just go anaerobic for extended periods of time
- Turtles and lungfishes rely on liver glycogen during submergence
- After maximal submergence liver glycogen not fully depleted
  - Additional glycogen stores in other tissues
  - More efficient fermentation pathways
  - Reduced metabolic rates
Metabolic depression extends turtle anoxia tolerance
Some animals learn to breathe through their skin
Lake Titicaca frog
hellbender
Mammalian divers

- **Weddell Seal** up to 10 ft long, 1000 pounds
- can dive over 2000 feet deep and stay submerged for 1.2 hours

Traits associated with diving performance
- Swimming styles - gliding
- Expanded blood volume, RBC mass, or hematocrit - Use of the spleen for RBC storage
- High muscle Mb
- Diving responses
  - Bradycardia
  - Peripheral vasoconstriction
  - Low lactate accumulation