1 Evolution of Animal Diversity

Bio 103 Lecture

Dr. Largen

2 *What Am I?*

- ✓ Of some 1.5 million species of organisms known to science
  - – over two-thirds are animals
- ✓ Humans have a long history of studying animal diversity
  - – But do we always know what an animal is when we see one?

3 What is an animal?

- ✓ Animals
  - – eukaryotic
  - – multicellular
  - – heterotrophs
  - – lack cell walls
  - – have unique intercellular junctions

4 What is an animal?

- ✓ Animals
  - – Most are diploid
    - • except for haploid eggs and sperm
  - – proceed through a well-defined life cycle

5 Evolution of animals

- ✓ Animal kingdom probably originated from colonial protists
  - – in which cells gradually became more specialized and layered

6 Evolution of animals

- ✓ Ecological, geologic, or genetic factors may have caused the Cambrian explosion in animal diversity
  - – Cambrian fossils can be classified as ancient representatives of the familiar animal phyla

7 Characterizing the differences between animal phyla

- ✓ Animals can be classified according to pattern of development or body structure
  - – Embryologic development
    - • germ layers
    - • blastopore fate
  - – Symmetry
  - – Body plan
  - – Segmentation

8 Characterizing the differences between animal phyla

- ✓ Embryologic development
  - – germ layers
    - • what are they?
      - – three cell layers
        - » ectoderm - outer layer
        - » mesoderm - middle layer

- » endoderm - inner layer
- formed at gastrulation
  - » blastula with single layer of cells turns into a 3-layered embryo
- foreshadow the future organization of tissues
  - » the three embryonic layers differentiate into the tissues of the adult animal

9

10 Characterizing the differences between animal phyla

✓Embryologic development

- germ layers
  - diploblastic organisms
    - have two germ layers
      - » ectoderm - outer layer
      - » endoderm - inner layer
  - triploblastic organisms
    - have three germ layers
      - » ectoderm - outer layer
      - » mesoderm - middle layer
      - » endoderm - inner layer

11 Characterizing the differences between animal phyla

✓Embryologic development

- blastopore fate
  - what is the blastopore?
    - Early during embryonic development the embryo is a hollow ball of cells
    - a portion of this hollow ball invaginates inward to form an opening called the blastopore
      - » blastopore can be thought of as the first opening
      - » **this opening, the blastopore, becomes either the mouth or the anus of animals with body cavities**

12 Characterizing the differences between animal phyla

✓Embryologic development

- blastopore fate
  - protostomes
    - organisms in which the blastopore becomes the mouth
      - » the first (proto) opening becomes mouth
  - deuterostomes
    - orgainisms in which the blastopore becomes the anus
      - » the second (deutero) opening becomes the mouth

13

14

15 Characterizing the differences between animal phyla

✓Symmetry

- refers to the arrangement of body structures in relation to some axis of the body
- three types of symmetry
  - asymmetry
  - radial symmetry
  - bilateral symmetry

16 Characterizing the differences between animal phyla

✓Symmetry

- asymmetry

- lack of any defined symmetry
- **no** plane passing through the central axis can divide the organism into halves that are mirror images of each other
  - cutting the organism in half produces dissimilar halves
- exhibited by most members of the simplest phylum of animal kingdom
  - phylum Porifera - the sponges

17 ☐ Characterizing the differences between animal phyla

✓Symmetry

– radial symmetry

- can be bisected into roughly equal, mirror-image halves in any two-dimensional plane
  - multiple plans can be drawn through the central axis, each dividing the organism into two mirror images
- exhibited by members of three phyla
  - phylum Cnidaria - jellyfish, sea anemones, corals
  - phylum Ctenophora - sea walnuts, comb jellies
  - phylum Echinodermata - sea stars& urchins, sand dollars
    - » radial symmetry seen in ADULTS in this phylum

18 

19 ☐ Characterizing the differences between animal phyla

✓Symmetry

– bilateral symmetry

- can be bisected into roughly equal, mirror-image halves in only one plane (the sagittal plane)
  - only one plane can be drawn through the central axis which divides the organism into two mirror images
- exhibited in all other animal phyla

20 ☐ Characterizing the differences between animal phyla

✓Symmetry

– bilateral symmetry

- a bilaterally symmetrical body plan has a
  - top - **dorsal** portion (upper surface)
  - bottom - **ventral** portion (lower surface)
  - front - **anterior** end (toward head)
  - back - **posterior** end (away from head)
  - side - **lateral** portion (left or right side)

21 

22 ☐ Characterizing the differences between animal phyla

✓Body plan

– a widely held system for grouping animal phyla is based on

- the presence/absence of a body cavity
- type of body cavity

23 ☐ Characterizing the differences between animal phyla

✓Body plan

– what is a body cavity?

- a fluid-filled space inside the body
  - this space may develop between
    - » between the mesoderm and endoderm, in which case its called a psuedocoel

» entirely within the mesoderm, in which case its called a coelom

24 Characterizing the differences between animal phyla

✓Body plan

– four types of body plans

- sac-like
- acoelomate
- pseudocoelomate
- coelomate

25 Characterizing the differences between animal phyla

✓Body plan

– **sac-like**

- simplest of body plans
- no formation of three embryonic germ layers
- no digestive system
- no body cavity
- exhibited by phyla that are asymmetrical or radially symmetrical as juveniles

26

27

28 Characterizing the differences between animal phyla

✓Body plan

– bilaterally symmetrical animals exhibit three basic body plans

- acoelomate
- pseudocoelomate
- coelomate

29

30 Characterizing the differences between animal phyla

✓Body plan

– **acoelomate**

- organisms that lack a body cavity
- have a solid body with a single opening to the outside, the mouth
- exhibited by
  - phylum Platyhelminthes - flatworms
  - a few other minor phyla

31

32 Characterizing the differences between animal phyla

✓Body plan

– **pseudocoelomate**

- organism with a body cavity
  - called a pseudocoel (*pseudo* = “false”)
  - which develops between the mesoderm and endoderm
    - » and therefore it is **not** completely lined with mesoderm
- exhibited by
  - phylum Nematoda - roundworms

- phylum Rotifera - wheel animals

33

34 Characterizing the differences between animal phyla

✓Body plan

- **coelomate**
  - organism with a body cavity
    - called a coelom
    - which develops entirely within the mesoderm
      - » and therefore it **is** completely lined with mesoderm
  - exhibited by many phyla
    - Mollusca, Annelida, Arthropoda, Echinodermata, Chordata
  - are either protostomes or deuterostomes

35

36 Characterizing the differences between animal phyla

✓Animals can be classified according to pattern of development or body structure

- Embryologic development
  - germ layers
  - blastopore fate
- Symmetry
- Body plan
- **Segmentation**

37 Characterizing the differences between animal phyla

✓Segmentation

- a key transition in animal body plan involved the subdivision of the body into segments
- segmentation underlies the organization of all advanced animals
- examples
  - repeating segments of earthworms
  - repeating vertebrae in vertebrates

38

39 Major phyla of the animal kingdom

✓**Protostome coelomates** represented by

- phylum Mollusca - snails, clams, chiton, octopus, squids (~110,000 species)
- phylum Annelida - earthworms, polychaetes, leeches (~12,000 species)
- phylum Arthropoda - horseshoe crabs, shrimps, insects, spiders, centipedes, millipedes (~1,000,000 species)

40 Major phyla of the animal kingdom

✓**Deuterostome coelomates** represented by

- phylum Echinodermata - sea lillies, sea stars, sea urchins, sea cucumbers (~6,000 species)
- phylum Hemichordata - acorn worms (~90 species)
- phylum Chordata - chordates (~42,500 species)
  - subphylum Urochordata - tunicates
  - subphylum Cephalochordata - lancelets

- subphylum Vertebrata - fish, amphibians, reptiles, birds, mammals

41 ## Some animals lack a body cavity

✓Sponges, cnidarians, and flatworms lack a body cavity

42 ## INVERTEBRATES

✓ **Sponges** (Phylum Porifera)
- have relatively simple, porous body
- phylum Porifera
- among simplest animals
- Many are radially symmetrical
- parts are arranged around a central axis
- flagellated choanocytes filter food from water passing through porous body

43 ## INVERTEBRATES

✓ **Sponges** (Phylum Porifera)
- lineage arose very early
  - probably evolved from multicellular choanoflagellates
    - group that most likely gave rise to animal kingdom

44 ## Invertebrates

✓ **Cnidarians** (Phylum Cnidaria)
- radial animals with stinging threads
- simplest animals with tissues
- exist in two radially symmetrical forms
  - Polyps
    - such as hydra, corals, and sea anemones
  - Medusas
    - jellies

45

46

47 ## Invertebrates

✓ **Cnidarians** (Phylum Cnidaria)
- Cnidocytes on their tentacles sting prey
  - tentacles
    - controlled by nerves
    - push food through mouth into a gastrovascular cavity
      - » where food is digested and then distributed
- only two cell layers are produced during gastrulation

48 ## Most animals are bilaterally symmetrical

✓ have mirror-image right and left sides
- a head with sensory structures
- move headfirst through their environment

49 Flatworms are the simplest bilateral animals

- ✓ **Flatworms** (Phylum Platyhelminthes)
  - – also called planaria
  - – have a simple nervous system
    - • consisting of brain, sense organs, and branching nerves
  - – as in cnidarians, mouth is only opening for its gastrovascular cavity

50 Flatworms are the simplest bilateral animals

- ✓ **Flatworms** (Phylum Platyhelminthes)
  - – flukes and tapeworms are parasitic flatworms with complex life cycles

51 Most animals have a body cavity

- ✓ Sponges, cnidarians, and flatworms lack a body cavity
- ✓ Nearly all other animals have a body cavity
- ✓ body cavity
  - – fluid-filled space between digestive tract and body wall
  - – aids in movement, cushions organs, and it may help in circulation

52

53 **Roundworms have a pseudocoelom and a complete digestive tract**

- ✓ **Nematodes** (Phylum Nematoda)
  - – have a body cavity not completely lined by mesoderm
  - – like most animals, they possess a complete digestive tract
    - • a tube with a mouth and an anus
  - – many are free-living
  - – others are parasites

54

55 **Diverse mollusks are variations on a common body plan**

- ✓ **Mollusks** (Phylum Mollusca)
  - – large and diverse phylum
    - • includes
      - – gastropods, such as snails and slugs
      - – bivalves, such as clams and scallops
      - – cephalopods, such as squids and octopuses

56

57

58

59 **Diverse mollusks are variations on a common body plan**

- ✓ **Mollusks** (Phylum Mollusca)
  - – all have a muscular foot and a mantle

- mantle may secrete a shell
  - which encloses visceral mass
- have true coelom
- have circulatory system
- many feed with a rasping radula

60 ☐ Many animals have a segmented body

✓ Segmentation
- the subdivision of some or most of the body into a series of repeated parts, or segments
- probably evolved as an adaptation for movement

61 ☐

62 ☐ **Earthworms and other annelids are segmented worms**

✓ **Annelids** (Phylum Annelida)
- their segmented bodies give them added mobility for swimming and burrowing
  - an earthworm eats its way through soi
  - polychaetes search for prey on seafloor or live in tubes and filter food particles
  - most leeches are free-living carnivores, but some suck blood

63 ☐

✓ s

64 ☐

65 ☐ **Arthropods are the most numerous and widespread of all animals**

✓ **Arthropods** (Phylum Arthropoda)
- segmented animals
- have exoskeletons
- have jointed appendages
- are most successful phylum of animals
  - in terms of numbers, distribution, and diversity, they
- Horseshoe crabs are ancient marine arthropods

66 ☐

67 ☐

68 ☐ **Arthropods are the most numerous and widespread of all animals**

✓ **Arthropods** (Phylum Arthropoda)
- most arachnids are terrestrial and carnivorous
- crustaceans are nearly all aquatic
- millipedes and centipedes make up a fourth group of arthropods

69 ☐

70 ☐

71 ☐

72 ☐ Insects are the most diverse group of organisms

✓ **Insects**

– most numerous and successful arthropods
– have three-part body consisting of
  • head, thorax, and abdomen
  • three sets of legs
  • wings (most, but not all insects)
– development of many insects includes metamorphosis

73 

74 ☐ Insects are the most diverse group of organisms

✓ **Insect metamorphosis**

– incomplete metamorphosis
  • young resemble adults, but are smaller with different body proportions
– complete metamorphosis
  • larvae specialized for eating & growing
    – larvae look different from adults
    – adults are specialized for dispersal and reproduction

75 

76 

77 

78 ☐ **Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement**

✓ **Echinoderms** (Phylum Echinodermata)

– includes sea stars and sea urchins
– are radially symmetrical as adults
– some have water vascular system
  • has suction-cup-like tube feet used for respiration and locomotion

79 

80 

81 ☐ Our own phylum, Chordata, is distinguished by four features

✓ **Chordates** (Phylum Chordata)

– segmented animals
– with four distinctive features
  • dorsal hollow nerve cord
  • stiff notochord
  • pharyngeal slits behind the mouth
  • muscular post-anal tail

82 Our own phylum, Chordata, is distinguished by four features

- ✓ **Chordates** (Phylum Chordata)
  - simplest are tunicates and lancelets
    - are marine invertebrates

83

84

85 A skull and a backbone are hallmarks of vertebrates

- ✓ **Vertebrates**
  - Most chordates are vertebrates
  - endoskeletons include a skull
  - backbone is composed of vertebrae

86

87 A skull and a backbone are hallmarks of vertebrates

- ✓ **Vertebrates**
  - most vertebrates have hinged jaws
  - lampreys lack hinged jaws
    - are classified as agnathans
  - jaws evolved by modification of skeletal supports of gill slits

88

89 Fishes are jawed vertebrates with gills and paired fins

- ✓ **Vertebrates**
  - two classes of fish
    - Chondrichthyes
      - cartilaginous fishes such as sharks
    - Osteichthyes
      - bony fishes such as tuna and trout

90

91 Fishes are jawed vertebrates with gills and paired fins

- ✓ **Vertebrates**
  - Bony fishes
    - more diverse and have
    - more mobile fins
    - operculi that move water over the gills
    - a buoyant swim bladder

92

93 Fishes are jawed vertebrates with gills and paired fins

✓ **Vertebrates**
- – Bony fishes
  - • three major classes of bony fishes
    - – Ray-finned fishes
    - – Lobe-finned fishes
    - – Lungfishes

94

95 Amphibians were the first land vertebrates

✓ **Vertebrates**
- – Class Amphibia
  - • represented today by
    - – frogs
    - – toads
    - – salamanders

96 Amphibians were the first land vertebrates

✓ **Vertebrates**
- – Class Amphibia
  - • Amphibians were the first terrestrial vertebrates
    - – limbs allow them to move on land
    - – larvae must develop in water

97

98 Reptiles have more terrestrial adaptations than amphibians

✓ **Vertebrates**
- – Class Reptilia
  - • able to live on land due to
    - – waterproof scales
    - – a shelled, amniotic egg
  - • modern reptiles are ectotherms
    - – warm their bodies by absorbing heat from environment

99

100 Reptiles have more terrestrial adaptations than amphibians

✓ **Vertebrates**
- – Class Reptilia
  - • dinosaurs were most diverse reptiles to inhabit land
    - – included some of the largest land animals ever
    - – may have been endothermic, producing their own body heat

101

102 Birds share many features with their reptilian ancestors

✓ **Vertebrates**
- – Class Aves

- like reptiles, this class has
  - scales
  - amniotic eggs

103 ## Birds share many features with their reptilian ancestors

✓ **Vertebrates**
- Class Aves
  - other bird characteristics include
    - wings
    - feathers
    - an endothermic metabolism
    - hollow bones
    - a highly efficient circulatory system

104

105 ## Mammals also evolved from reptiles

✓ **Vertebrates**
- Class Mammalia
  - descended from reptiles
  - are endothermic
  - have two unique characteristics
    - hair, which insulates the body
    - mammary glands
      - » which produce milk that nourishes their young

106 ## Mammals also evolved from reptiles

✓ **Vertebrates**
- Class Mammalia
  - most give birth to young after a period of embryonic development inside body of the mother
    - embryo is nurtured by an organ called the placenta
  - a few mammals lay eggs
    - monotremes

107

108 ## Mammals also evolved from reptiles

✓ **Vertebrates**
- Class Mammalia
  - marsupials
    - have a short gestation

109

110 ## Mammals also evolved from reptiles

✓ **Vertebrates**
- Class Mammalia
  - most are eutherians, also called placentals

– have a relatively long gestation
– complete embryonic development occurs within the mother

111

112 ## PHYLOGENY OF THE ANIMAL KINGDOM

✓ phylogenetic tree
– gives animal diversity an evolutionary perspective
– traditional phylogenetic tree is based on
• patterns of embryonic development
• some fundamental structures
– molecular-based tree has added two clades within the protostomes

113

114

✓ Burgess Shale fossils

115

✓ Sponges

116

✓ Coral polyps

117

✓ Purple striped jelly, *Pelagia panopyra*

118

✓ Lion mane jelly

119

✓ Sea anemones

120

✓ Cnidarians: jellies, sea anemone, coral polyps

121

✓ Ctenophore

122

✓ Flatworm

123

✓ Roundworm, *C. elegans*

124

✓ Deer Cowrie, a marine gastropod with a shell

125

✓ Earthworm

126

✓ Beetle

127

✓Butterfly metamorphosis: larva (caterpillar), pupa, emerging adult, adult

128

✓Sea star, Bloodstar

129

✓Brittle star

130

✓Cartilaginous fishes: sharks and rays

131

✓Newt

132

✓Extant reptiles: desert tortoise, lizard, King snake, alligators

133

✓Sea turtle

134

✓Banded gecko

135

✓Emerald tree boa

136

✓Penguins, flightless birds

137

✓Marsupial mouse

138 The End.