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Life: A Tour of the Kingdoms of Life

EVPP 110 Lecture
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2
The Bacterial Kingdoms

✓ Prokaryotes
- fundamentally different from eukaryotes
  - lack true, membrane-bound nucleus
  - lack membrane-bound organelles
- classified into two domains, 2 kingdoms
  - Domain Archaea (Kingdom Archaebacteria)
    - from Greek *archaios* ("ancient")
  - Domain Bacteria (Kingdom Eubacteria)
    - diverged from Archaea

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The Bacterial Kingdoms

✓ Prokaryotes
- nearly all have a cell wall
  - bacteria - w/ peptidoglycan
  - archaea - w/o peptidoglycan

✓ Evolutionary path
- archaea -more like eukaryotes than other prokaryote group (bacteria)
- current hypothesis - archaea & eukaryotes evolved from common ancestor

4 Figure 27.5 Gram-positive and gram-negative bacteria (Campbell & Reece)

5
The Bacterial Kingdoms

✓ Prokaryotes (Archaea & Bacteria)
- divided into two kingdoms
  - archaebacteria
  - eubacteria

6
Kingdom Archaebacteria

7
Kingdom Archaebacteria

✓ Archaebacteria
- differ in form and metabolism from other living things
- found in areas sheltered from evolutionary alteration
  - unchanging habitats
    - resemble earth's early environment
- living relics
  - surviving representatives of first ages of life on earth

8
Kingdom Archaebacteria

- Archaebacteria
  - found in extreme environments
    - oxygen-free depths
      - such as Black Sea
    - boiling waters
      - springs
      - deep sea vents

9 Kingdom Archaebacteria

- Archaebacteria
  - examples
    - methanogens
      - anaerobic (live in absence of oxygen)
      - obtain energy by using CO_2 to oxidize H_2
        - producing methane (CH_4) as waste
    - extreme halophiles (salt lovers)
      - some require salt content 10X greater than seawater
    - extreme thermophiles (heat lovers)
      - optimum temp for most is 60-80 degrees C

10

11 Figure 27.14 Extreme halophiles (Campbell & Reece)

12 Figure 27.14x1 Hot springs, home of thermophiles (Campbell & Reece)

13 Figure 27.1 "Heat-loving" prokaryotes (Campbell & Reece)

14 Kingdom Eubacteria

15 **Kingdom Eubacteria**

- shapes
- modes of nutrition
- examples of structural features that aid in survival

16 **Kingdom Eubacteria**

- Eubacteria
  - "eu" = "true"
  - true bacteria
  - three most common cell shapes
    - **spherical**
    - **rod-like**
    - **spiral**

17 **Kingdom Eubacteria**

- **spherical**
  - **cocci (coccus)**, from Greek for berries
  - clusters or chains
  - strep throat is caused by a streptococcus
- **rod-like**
  - called **bacilli (bacillus)**
  - most occur singly, some in pairs, chains
  - anthrax is caused by a bacillus
- **helical (spiral)**
  - called **spirilla** (helical)**, vibrios** (comma)**, spirochetes** (curved, long, flexible)

18 Figure 27.3 The most common shapes of prokaryotes (Campbell & Reece)

19 **Kingdom Eubacteria**

- ✓ Prokaryotes exhibit greater nutritional diversity than eukaryotes
  - – **autotrophs**
    - **photoautotrophs**
    - **chemoautotrophs**
  - – **heterotrophs**
    - **photoheterotrophs**
    - **chemoheterotrophs**

20 **Kingdom Eubacteria**

- ✓ **Autotrophs** = “self-feeders”
  - – make organic compounds from inorganic sources
    - obtain carbon atoms from CO_2
  - – **photoautotrophs**
    - obtain energy from sunlight (cyanobacteria)
  - – **chemoautotrophs**
    - obtain energy from inorganic chemicals such as H_2S

21 Figure 27.11x1 Cyanobacteria: *Gloeothece* (top left), *Nostoc* (top right), *Calothrix* (bottom left), *Fischerella* (bottom right) (Campbell & Reece)

22 **Kingdom Eubacteria**

- ✓ **Heterotrophs** = “other-feeders”
  - – obtain carbon atoms from organic compounds
  - – **photoheterotrophs**
    - obtain energy from sunlight
  - – **chemoheterotrophs**
    - obtain energy from organic molecules
    - diverse, almost any organic molecule can serve as a food for some species
    - are dominant prokaryotes today

23 Table 27.1 Major Nutritional Modes (Campbell & Reece)

24 Diverse structural features help prokaryotes thrive almost everywhere

- ✓ Structural features help prokaryotes survive
  - – **pili**
  - – **endospore**

25 Diverse structural features help prokaryotes thrive almost everywhere

- ✓ **Pili**
  - – help bacteria stick to each other and to surfaces
  - – “sex pili” are required for initiating bacterial “mating” (conjugation)

26 Figure 27.6 Pili (Campbell & Reece)

27 Diverse structural features help prokaryotes thrive almost everywhere

- ✓ **Endospore**
  - – “resting cell”, enables certain bacteria to survive long periods of harsh conditions
  - – inner cell can withstand lack of water & nutrients, extreme heat & cold, most poisons
  - – anthrax forms endospores

28 Figure 27.10 An anthrax endospore (Campbell & Reece)

29 Figure 27.10x Endospores (Campbell & Reece)

30 Figure 27.17 Lyme disease, a bacterial disease transmitted by ticks (Campbell & Reece)

31 Figure 27.4x2 Prokaryotes and eukaryotic cell (Campbell & Reece)

32

33 # Kingdom Protista

34 Protists - unicellular eukaryotes and their close relatives

- ✓ **Protists**
  - – diverse group of mostly unicellular eukaryotes
  - – classification
    - **Domain Eukarya**
    - **Kingdom Protista**
      - – traditional placement
      - – these organisms probably constitute several kingdoms

35 Protists - unicellular eukaryotes and their close relatives

- ✓ Characteristics of **protists**
  - – nutritional modes
    - autotrophic
      - – traditionally called **algae**
    - heterotrophic
      - – eat bacteria, protists or organic matter
    - mixotrophic
      - – combine photosynthesis and heterotrophic nutrition, as in *Euglena*

36 Protists - unicellular eukaryotes and their close relatives

- ✓ Characteristics of **protists**
  - – assemblage
    - unicellular
    - colonical
    - mutlicellular

37 Protists - unicellular eukaryotes and their close relatives

- ✓ Characteristics of **protists**
  - – habitats
    - aquatic
      - – freshwater & marine
    - terrestrial
      - – rotting logs, other decaying organic matter
    - aerobic
      - – pond water
    - anaerobic
      - – mud at bottom of lakes
      - – digestive tract of animals

38 **Protistan diversity**

- ✓ Major groups
  - – diplomonads-parabasalids
  - – euglenozoa
  - – alveolates
  - – stramenopiles
  - – red algae
  - – green algae
  - – slime molds
  - – psuedopod-equipped protists of uncertain phylogeny

39 **Protistan diversity**

- ✓ **Diplomonads-parabasalids**

- examples
  - diplomonad ***Giardia lamblia***
    - parasite that infects human intestine
  - parabasalid ***Trichomonas vaginalis***
    - common inhabitant of vagina of human females
    - populations explode when pH is abnormal

40 Figure 28.9 *Giardia lamblia*, a diplomonad

41 Figure 28.10 *Trichomonas vaginalis*, a parabasalid

42 **Protistan diversity**

✓ **Euglenozoa**
- two major groups
  - **euglenoids**
    - ***Euglena*** sp.
      - » "plant-like" (photosynthetic), "animal like" (heterotrophic)
  - **kinetoplastids**
    - ***Trypanosoma*** sp.
      - » obtain nutrients from vertebrate blood
      - » cause sleeping sickness (human disease)

43 Figure 28.3 *Euglena*: an example of a single–celled protist

44 Figure 28.03x *Euglena*

45 Figure 28.11x *Trypanosoma*, the kinetoplastid that causes sleeping sickness

46 **Protistan diversity**

✓ **Alveolates**
- three subgroups
  - **dinoflagellates**
  - **apicomplexans**
  - **ciliates**

47 **Protistan diversity**

✓ **Alveolates**
- **dinoflagellates**
  - blooms cause red tides, producing fish kills
  - example
    - ***Pfesteria piscicida***
      - » carnivorous; stuns fish with toxin, feeds on prey's body fluids
      - » has caused problem in fish in Potomac in recent years

48 Figure 28.12 A dinoflagellate

49 Figure 28.12x1 Dinoflagellate

50 Figure 28.12x2 Swimming with bioluminescent dinoflagellates

51 **Protistan diversity**

✓ **Alveolates**
- **apicomplexans**
  - parasitic
    - example
    - ***Plasmodium*** sp. causes malaria

52 Figure 28.13 The two-host life history of *Plasmodium*, the apicomplexan that causes malaria

53 **Protistan diversity**

- ✓ **Alveolates**
  - – **ciliates**
    - most are solitary, freshwater organisms
    - example
      - – ***Paramecium*** sp

54 Figure 28.14c Ciliates: *Paramecium*

55 Figure 28.14x Ciliates: *Stentor* (left), *Paramecium* (right)

56 Figure 28.15x *Paramecium* conjugating

57 **Protistan diversity**

- ✓ **Stramenopiles**
  - – several subgroups
    - **water molds** and their relatives
    - **diatoms**
    - **golden algae**
    - **brown algae**

58 **Protistan diversity**

- ✓ **Stramenopiles**
  - – **water molds (& relatives white rusts, downy mildews)**
    - most decomposers, some parasitic on fish, other parasitic on land plants
      - – ***Phytophthora infestans*** that caused potato blight

59 Figure 28.16 The life cycle of a water mold (Layer 3)

60 Figure 28.16x2 Water mold: *Oogonium*

61 Figure 28.x2 Powdery mildew

62 **Protistan diversity**

- ✓ **Stramenopiles**
  - – **diatoms**
    - unique, glassy cell wall that contains silica

63 Figure 28.1b Too diverse for one kingdom: a diatom, a unicellular "alga"

64 Figure 28.17 Diatoms: Diatom diversity (left), *Pinnularia* (left)

65 Figure 28.17x Diatom shell

66 **Protistan diversity**

- ✓ **Stramenopiles**
  - – **golden algae**

67 Figure 28.18 A golden alga

68 **Protistan diversity**

- ✓ **Stramenopiles**
  - – **brown algae**
    - all multicellular
    - most are marine algae
    - example is **kelp**

69 Figure 28.1d Too diverse for one kingdom: Australian bull kelp (*Durvillea potatorum*)

70 Figure 28.20x1 Kelp forest

71 Figure 28.20x2 Kelp forest

72 **Protistan diversity**

- ✓ **Red algae**
  - – most are multicellular
  - – largest are also called "**seaweeds**"

73 Figure 28.22 Red algae: Dulse (top), *Bonnemaisonia hamifera* (bottom)

74 **Protistan diversity**

- ✓ **green algae**
  - – some unicellular, some colonial
  - – share many features with plants
    - is thought that ancient green algae gave rise to first plants

75 Figure 28.23 Colonial and multicellular chlorophytes: *Volvox* (left), *Caulerpa* (right)

76 Figure 28.x3 *Spirogyra* conjugating

77 **Protistan diversity**

- ✓ **Slime molds**
  - – also known as mycetozoa which means "fungus animal"
  - – two types of slime molds
    - **plasmodial slime molds**
    - **cellular slime molds**

78 Plasmodial slime molds have brightly colored stages with many nuclei

- ✓ **Plasmodial slime molds**
  - – common where there is moist, decaying organic matter
  - – unicellular - but may grow to a size of several centimeters in diameter

79 Figure 28.29x1 Plasmodial slime mold

80 Cellular slime molds have unicellular and muticellular stages

- ✓ **Cellular slime molds**
  - – lead a dual existence
    - have both unicellular & multicellular stages
  - – common on decaying organic matter
  - – typically have **three stages** in life cycle
    - **amoeboid cells**
    - **slug-like colony**
    - **multicellular reproductive structure**

81 Figure 28.30x1 *Dictyostelium* life cycle

82 **Protistan diversity**

- ✓ **psuedopod-equipped protists of uncertain phylogeny**
  - – three groups
    - amoebas
    - heliozoans and radiolarians
    - foraminiferans

83 **Protistan diversity**

- ✓ **psuedopod-equipped protists of uncertain phylogeny**
  - – **amoebas**
    - most species move and feed via **pseudopodia**
    - can assume any shape
    - live on rocks, sticks, in mud at bottom of lake or ocean

84 Figure 28.26 Use of pseudopodia for feeding

85 Figure 28.26x1 *Amoeba*

86 **Protistan diversity**

- ✓ **psuedopod-equipped protists of uncertain phylogeny**
  - – **heliozoans and radiolarians**
    - have slender pseuopodia called axopodia
    - aquatic, freshwater and marine

87 Figure 28.27 Actinopods: Heliozoan (left), radiolarian (right)

88 Figure 28.27x Radiolarian skeleton

89 **Protistan diversity**

- ✓ **psuedopod-equipped protists of uncertain phylogeny**
  - – **forams (foraminiferans)**
    - almost all marine
    - most live in sand or attach themselves to rocks and algae

90 Figure 28.28 Foraminiferan

91 Multicellular life may have evolved from colonial protists

- ✓ Multicellular organisms are fundamentally different from unicellular organisms
  - – unicellular organisms
    - life's activities occur within single cell
  - – multicellular organisms
    - various specialized cells
      - – perform different functions
      - – dependent on one another

92 Multicellular life may have evolved from colonial protists

- ✓ Multicellular organisms probably evolved from unicellular protists
  - – ancestral colony may have formed when a protist divided
    - offspring remained attached to one another
    - cells in colony became specialized and interdependent

93

94 Kingdom Fungi

95 Kingdom Fungi

- ✓ eukaryotic
- ✓ most are multicellular
- ✓ heterotrophic
  - – acquire nutrients via absorption
    - digests food outside body using enzymes
- ✓ ecological roles
  - – decomposers
  - – parasites
  - – mutualistic symbionts

96 Figure 31.0x Decomposers

97 Figure 31.6 The common mold *Rhizopus* decomposing strawberries

98 Figure 31.11 Basidiomycetes (club fungi):Greville's bolete (top left), turkey tail (bottom left), stinkhorn (right)

99 Figure 31.11x1 *Coprinus comatus*, Shaggy Mane

100 Figure 31.11x2 *Geastrum* triplex

101 Figure 31.11x3 *Tremella messenterica*, Witch's Butter

102 Figure 31.11x4 Stinkhorn

103 Figure 31.11x5 *Amanita*

104 Figure 31.13 A fairy ring

105 Figure 31.15 Budding yeast

106 Figure 31.16 Lichens

107 Figure 31.17 Anatomy of a lichen

108 Figure 31.20x2 Pink ear rot of corn

109 Kingdom Plantae

110 Kingdom Plantae

- ✓ eukaryotic
- ✓ multicellular
- ✓ evolved from algae
- ✓ autotrophs
  - photosynthetic
- ✓ ecological role
  - producers
    - base of food chains

111 Figure 29.0 Ferns

112 Figure 29.15 Bryophytes

113 Figure 30.5a Phylum Ginkgophyta: *Ginkgo biloba*

114 Figure 30.8a Phylum Coniferophyta: Douglas fir

115 Figure 30.8b Phylum Coniferophyta: Sequoia

116 Kingdom Animalia

117 Kingdom Animalia

- ✓ eukaryotes
- ✓ all are multicellular
- ✓ heterotrophic
- ✓ ecological roles
  - varied

118 Figure 33.0 Ochre sea stars, *Pisaster ochraceus*

119 Figure 33.2 Sponges

120 Figure 33.4bx Jelly medusa

121 Figure 33.6 Cnidarians: Hydrozoans (top left), jelly (top right), sea anemone (bottom left), coral polyps (bottom right)

122 Figure 33.6bx Purple striped jelly, *Pelagia panopyra*

123 Figure 33.6cx Sea anemones

124 Figure 33.6dx Coral polyps

125 Figure 33.9x A flatworm

126 Figure 33.11 The life history of a blood fluke, *Schistosoma mansoni*

127 Figure 33.12 Anatomy of a tapeworm

128 Figure 33.13 A rotifer

129 Figure 33.17 A chiton

130 Figure 33.18x Garden snail

131 Figure 33.19 Gastropods: Nudibranchs (top left and bottom left), terrestrial snail (bottom left), deer cowrie (bottom right)

132 Figure 33.20 A bivalve: Scallop

133 Figure 33.22 Cephalopods: Squid (top left and bottom left), nautilus (top right), octopus (bottom right)

134 Figure 33.23x External anatomy of an earthworm

135 Figure 33.24 Annelids, the segmented worms: Polychaete (left), feather-duster worm (middle), leech (right)

136 Figure 33.24cx Christmas-tree worms

137 Figure 33.25a Free-living nematode

138 Figure 33.26 External anatomy of an arthropod

139 Figure 33.28 Horseshoe crabs, *Limulus polyphemus*

140 Figure 33.29 Arachnids: Scorpion (left), honeybee air tube filled with parasitic mites (right)

141 Figure 33.37 Echinoderms: Sea star (top left), brittle star (top right), sea urchin (bottom left), sea lily (bottom right),

142 Figure 34.0 A snake skeleton exhibits defining characteristic of a vertebrate

143 Figure 34.11 Cartilaginous fishes (class Chondrichthyes): Great white shark (top left), silky shark (top right), southern stingray (bottom left), blue spotted stingray (bottom right)

144 Figure 34.12a Ray-finned fishes (class Actinopterygii): yellow perch

145 Figure 34.12b Ray-finned fishes (class Actinopterygii): long-snouted sea horse

146 Figure 34.14 A coelocanth (*Latimeria*), the only extant lobe-finned genus

147 Figure 34.17 Amphibian orders: Newt (left), frog (right)

148 Figure 34.17x1 Frogs

149 Figure 34.18 "Dual life" of a frog *(Rana temporaria)*

150 Figure 34.24 Extant reptiles: Desert tortoise (top left), lizard (top right), king snake (bottom left), alligators (bottom right)

151 Figure 34.24cx Emerald tree boa

152 Figure 34.29 A small sample of birds: Blue-footed boobies (top left), male peacock (top right), penguins (bottom left), perching bird (bottom right)

153 Figure 34.31 Australian monotremes and marsupials: echidna (top left), marsupial mouse (lower left), sugar glider (right)

154 Figure 34.34 Prosimians: Lemurs

155 Figure 34.36 A capuchin, a New World monkey (left), and a vervet, an Old World monkey (right)

156 Figure 34.37 Apes: Gibbon (top left), orangutan (top right), gorilla (bottom left), chimpanzee (bottom right)

157 Figure 34.40 Turkana boy

158 The End.