DISCOVERING THE WALLACE LINE

BACKGROUND

This activity supports the HHMI short film *The Origin of Species: The Making of a Theory*. Students are presented with a map of the Malay Archipelago and a series of observations of animals. By plotting which animals are found on which island, the students discover the Wallace Line, a sharp boundary that separates distinct Asian and Australian fauna.

KEY CONCEPTS AND LEARNING OBJECTIVES

- New species of animals arise from other preexisting species.
- Groups of animals that evolve isolated from each other lead to distinct groups of species.
- Natural boundaries can prevent animals in adjacent regions from mixing even if those regions offer similar climates and habitats.
- Earth is dynamic and has undergone vast changes over geologic and evolutionary timescales.

After completing this activity, students should be able to:

- Organize data to draw conclusions
- Evaluate and refine conclusions based upon new data
- Summarize the importance of Wallace's observations to the theory of evolution

CURRICULUM AND TEXTBOOK CONNECTIONS

Curriculum	**Standards**
AP Biology (2012-13 Standards)	1.A.1, 1.A.4
IB (2009 Standards)	5.4, D2,
NGSS	MS-LS2-4, MS-LS4-1, HS-LS4-1, HS-LS4-2, HS-LS4-5, MS-LS4.A, MS-LS4.B, MS-LS4.C, MS-ESS1.C, HS-LS4.A, HS-LS4.B, HS-LS4.C
Textbook	**Chapter Sections**
Miller & Levine, *Biology* (2010 ed.)	Chapters 16-17, 19
Reese *et al*., *Campbell Biology* (9th ed.)	Chapters 1.2-3, 22-25

KEY TERMS

Biogeography, continental shelf, evolution, fauna, faunal assemblage, geology, habitats, Malay Archipelago, plate tectonics, reproductive isolation, species

TIME REQUIREMENTS

This activity could fill two 50-minute class periods or a single longer period of around 90 minutes (including time to watch the 30 minute film).

SUGGESTED AUDIENCE

This activity is appropriate for middle school and high school Biology and Earth Science classrooms.

PRIOR KNOWLEDGE

Students should understand that: the Malay Archipelago is located between Australia and Southeast Asia, continents move, and sea levels change over long timescales.

MATERIALS

Students will need:

- The student version of these materials with a map and associated data sheets
- Colored pencils
- Access to a computer to watch the film and the supplemental animations (*Wallace Line Plate Tectonics* and *Wallace Line Sea Level*). The film and animations are all available for download on BioInteractive.org

SUGGESTED PROCEDURE

1. Have students read the Introduction, which briefly introduces students to Wallace and his observations, and then direct them to do Part 1: Field Studies.

2. After students draw their version of the Wallace Line and justify their choices, students are directed to watch the film, *The Origin of Species: The Making of a Theory*. Do this as whole-class activity or in students' working groups.

3. Wrap up the activity by returning to Part 2: Considering Continental Movement and Sea Level Change. For this part, students can use the two supplemental animations and/or the two handouts "Continents Move over Time" and "Changes in Sea Level" to answer questions. They also integrate what they learned during the film.

TEACHING TIPS

- Teachers might need to define "fauna" and "faunal assemblage" for students. Students should also be familiar with the terms listed under the "Key Terms" section.
- The faunal distributions are presented island by island as a way to represent how field data is commonly recorded. Suggest that students may want to create a summary table such as the one that appears on page 8 of these teacher materials. A summary

table will help students draw the boundaries for step 1 of the activity. Alternatively, you could provide the students with a copy of the summary table to save classroom time.

- Before watching the film, have students share (either in pairs, groups, or with the whole class) where they decided to place their boundary lines. Encourage students to explain their reasoning for the placement.
- The In-Depth Film Guide for Teachers provides suggestions about how students can take notes or keep track of information presented in the film, *The Origin of Species: The Making of a Theory.* Alternatively, students could complete the Student Quiz as they watch the film. Both are available at http://www.hhmi.org/biointeractive/film-guides-origin-species-making-theory.

ANSWERS

Part 1: Field Studies

1. For each type of animal listed below, draw a boundary on the map that includes all the locations where specimens of that animal have been found. Use different colors or patterns to distinguish the lines for each order.

	Latin Family	Common
A.	Cacatuidae	Cockatoos
B.	Cercopithecidae	Old World Monkeys
C.	Felidae	Cats
D.	Macropodidae	Kangaroos
E.	Megapodiidae	Mound-Building Birds
F.	Meliphagidae	Honeyeater Birds
G.	Paradisaeidae	Birds-of-paradise
H.	Picidae	Woodpeckers
I.	Ursidae	Bears
J.	Petauridae	Possums

2. What pattern emerges from the lines that you have drawn? Can you identify any groupings?
Students may observe two or three main groups of animals. Australia and New Guinea have the same faunal assemblage, as do the Malay Peninsula and Sumatra. The islands in between are a transition zone; the animals living on the

eastern islands are similar to those in Australia, while the animals living on the western islands are similar to those in Asia.

3. If you can, draw a boundary line that separates different faunal assemblages.
   Refer to the black line on the map.

4. Given that these islands have similar climates and habitats, suggest an explanation for why some islands have similar fauna while nearby islands have completely different fauna.
   Suggested answer: Animal species adapt to their environment and to fill certain niches. However, they must come from somewhere. Animals on the Asian side of the boundary evolved from Asian animals to fill niches on those islands. On the other side of the boundary, animals evolved from Australian animals to fill the niches on those islands. The species do not mix because niches on the other side of the boundary are already filled. There may also be some physical boundary that separates the islands.

Part 2: Considering Continental Movement and Sea Level Change

View the two supplemental animations and/or examine the attached figures that show how sea level and the continents have changed over time.

5. Evaluate the boundary line you drew for step 3. If, based upon the new information you've learned, you need to change your boundary line, do so now.
6. Use the figures and what you learned in the film to elaborate on the explanation that you wrote in question 4.
   Suggested answer: Australia was separated from Asia by vast distances, so animals in those places evolved in isolation from each other. Plate tectonics have brought those places together in modern days. In more recent times, drops in sea level due to ice ages connected islands on the west side of the boundary to each other and to the mainland, so the species all mixed. Deep water prevented the islands on the east side of the boundary from ever being connected to Asia, so the species that live there remain distinct from those on the other island.

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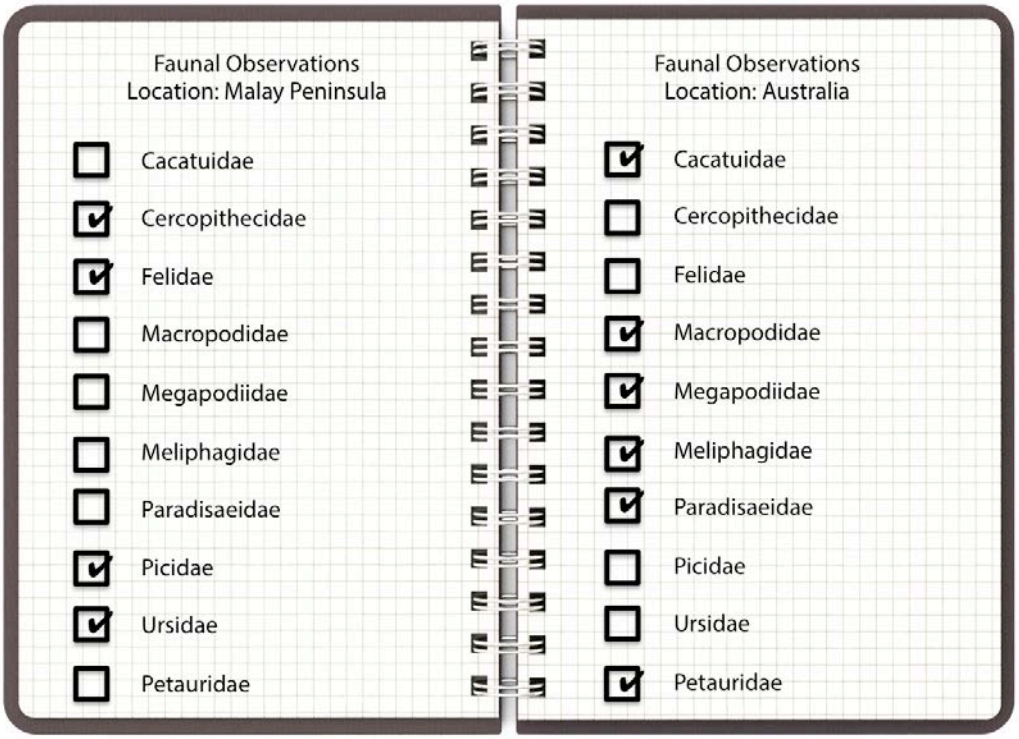
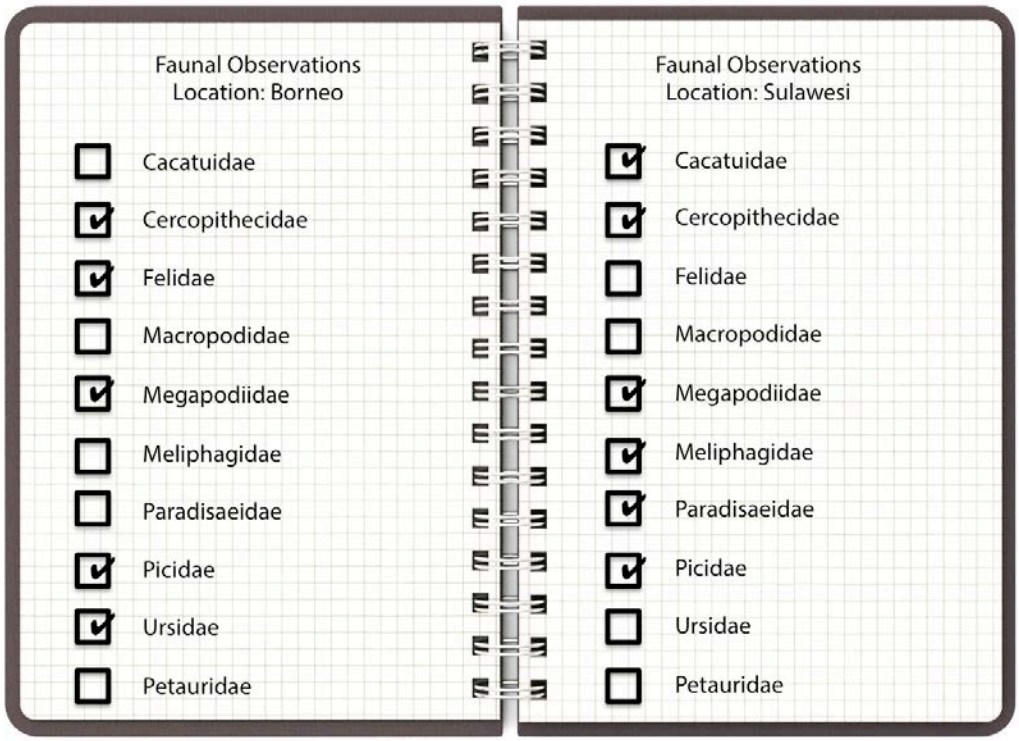
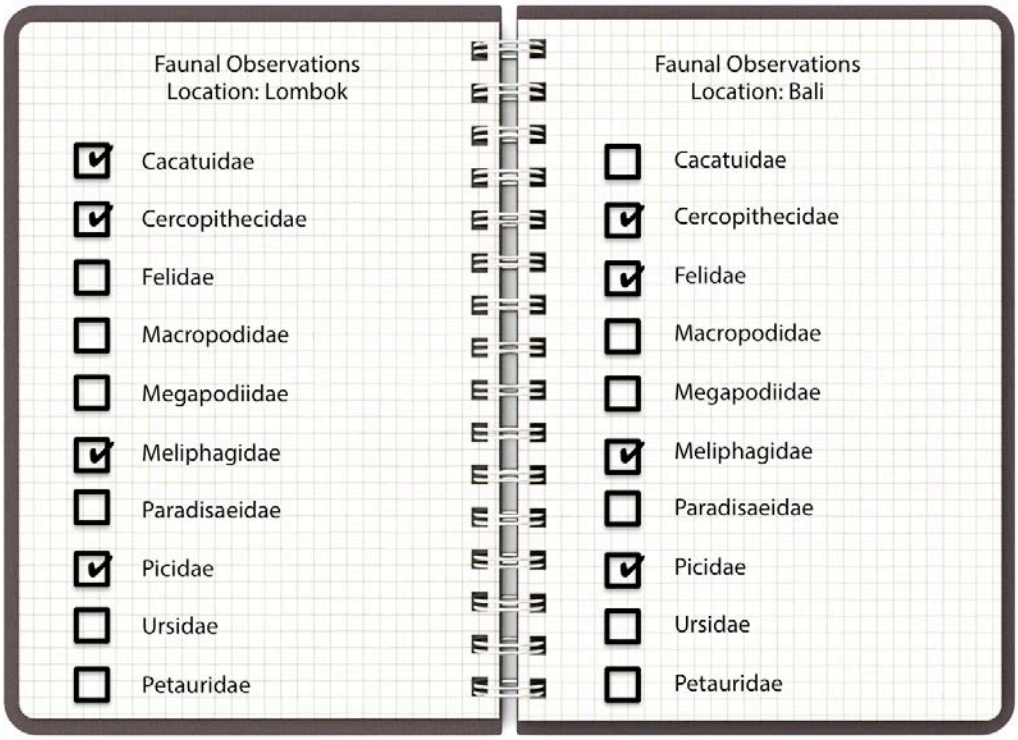
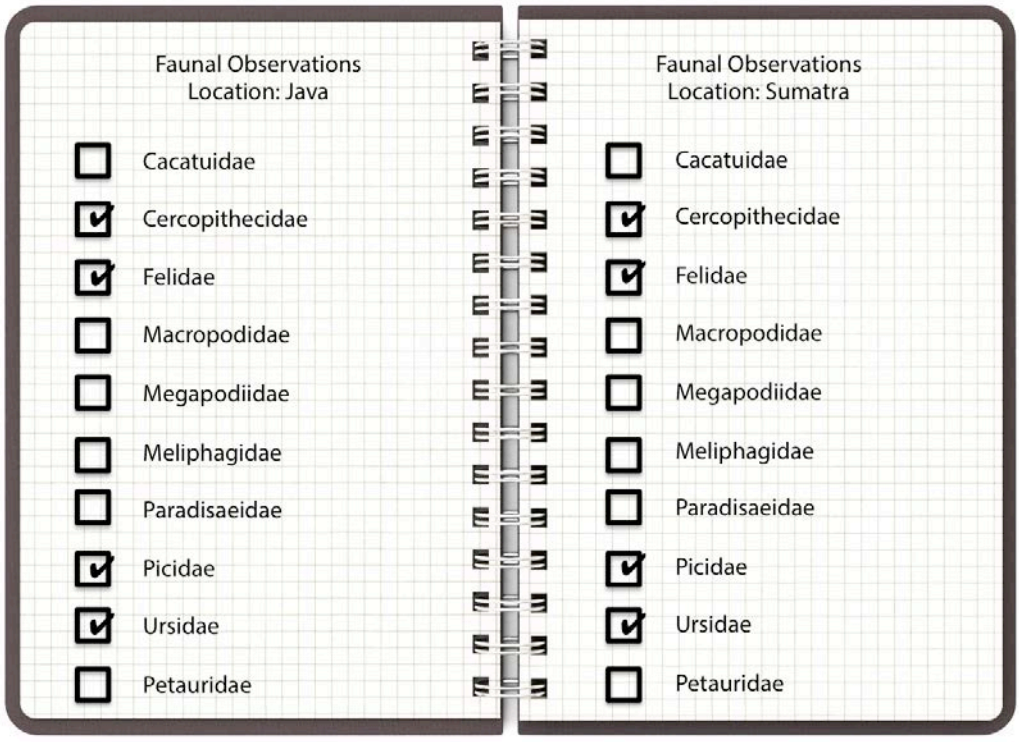
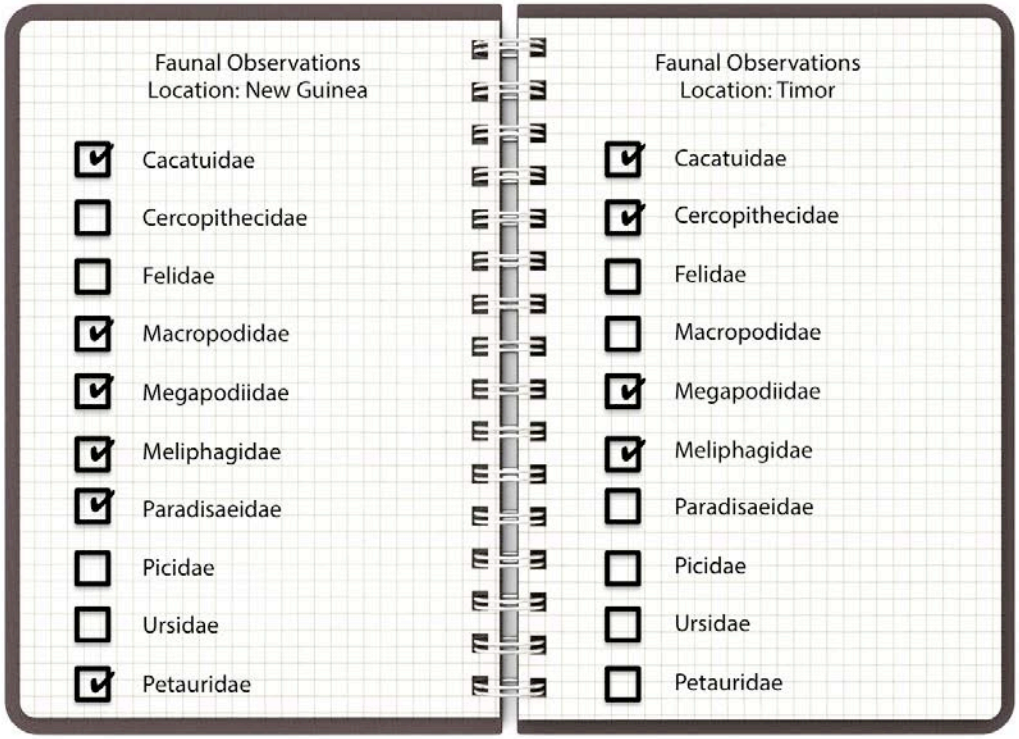

Faunal Observations
Location: Malay Peninsula
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae
Faunal Observations
Location: Australia
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae


Faunal Observations
Location: Borneo
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae
Faunal Observations
Location: Sulawesi
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae

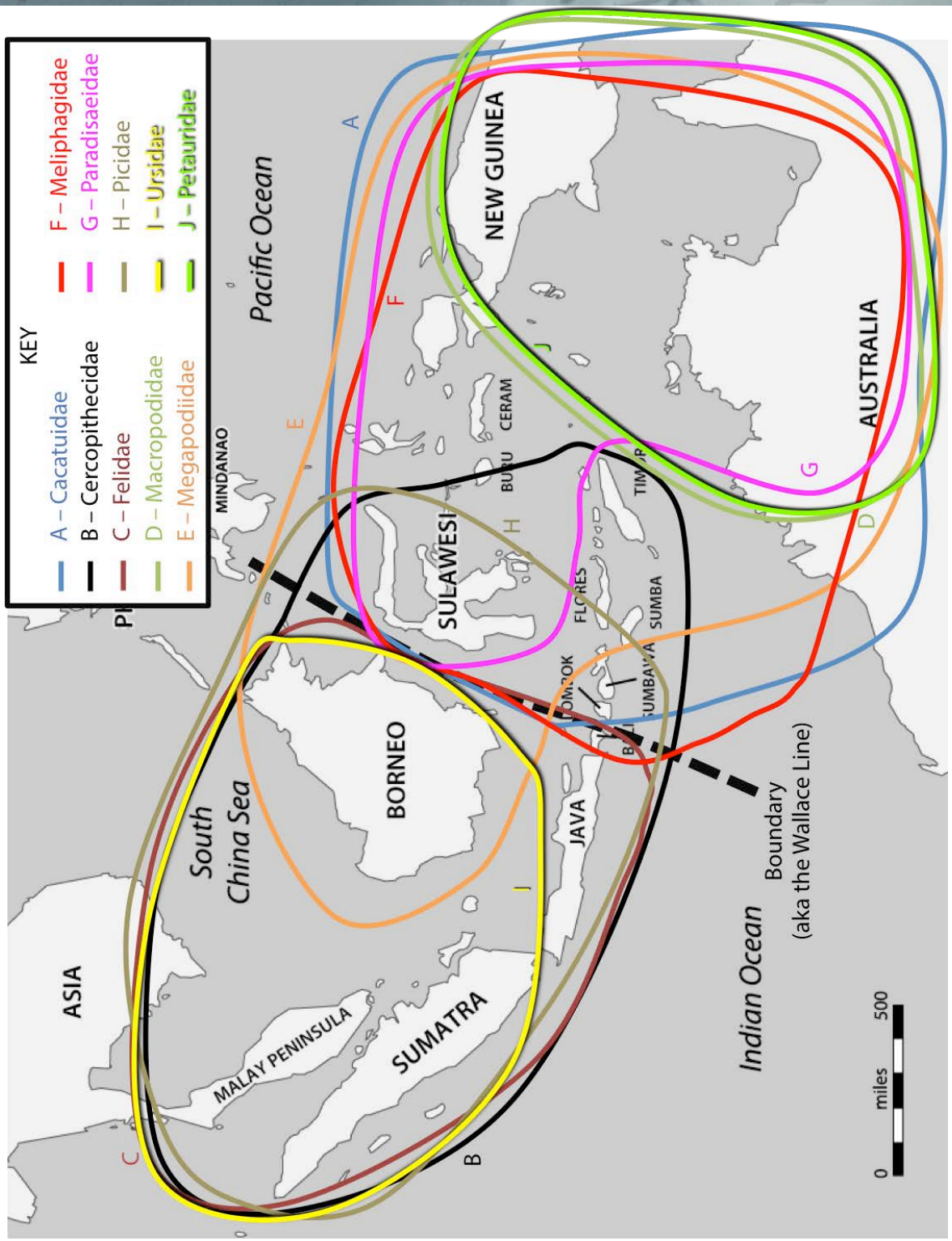

Faunal Observations
Location: Lombok
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae
Faunal Observations
Location: Bali
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae


Faunal Observations
Location: Java
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae
Faunal Observations
Location: Sumatra
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae


Faunal Observations
Location: New Guinea
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae
Faunal Observations
Location: Timor
Cacatuidae
Cercopithecidae
Felidae
Macropodidae
Megapodiidae
Meliphagidae
Paradisaeidae
Picidae
Ursidae
Petauridae

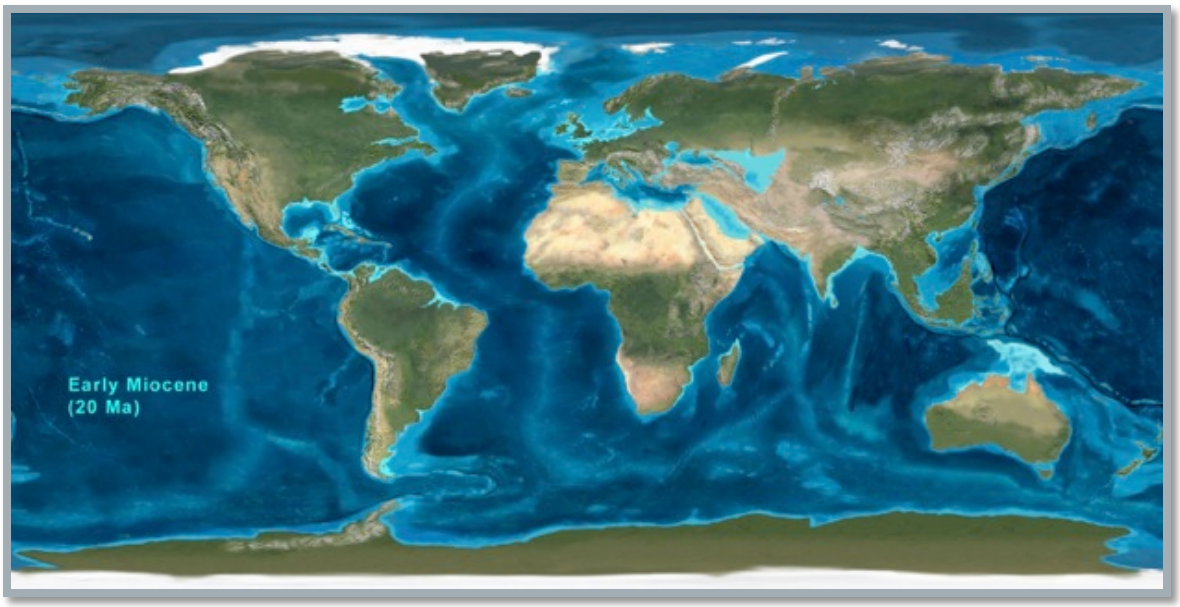
SUMMARY OF FIELD OBSERVATIONS

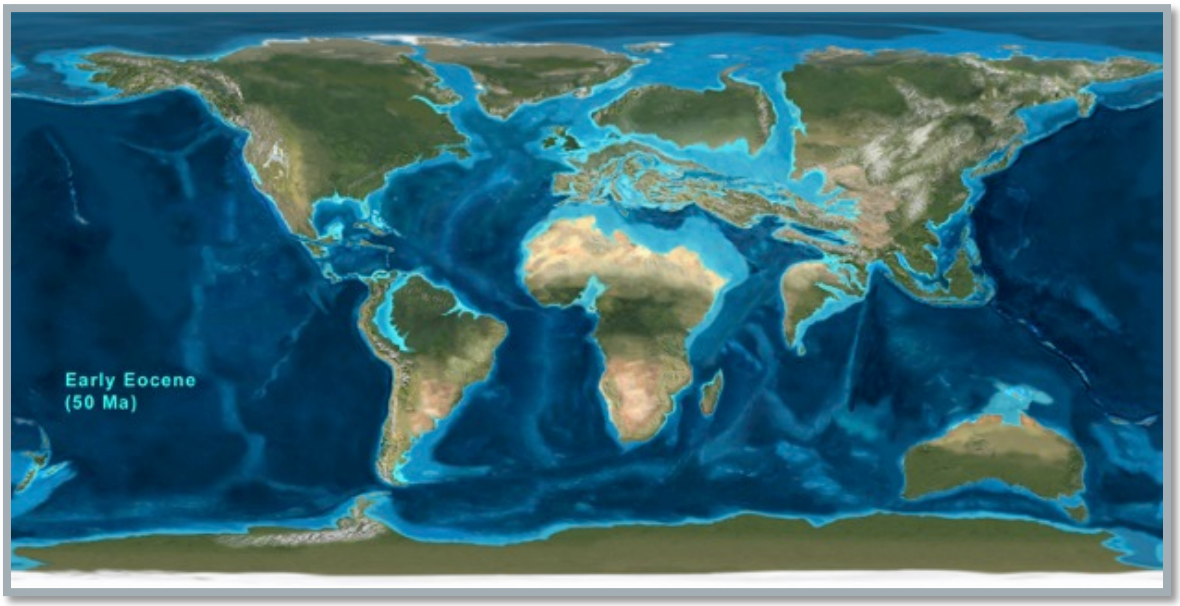
Latin Family	Common	Malaysia	Borneo	Sumatra	Java	Bali	Sulawesi	New Guinea	Timor	Lombok	Australia
Filidae	Cats	Y	Y	Y	Y	Y					
Macropodidae	Kangaroos							Y			Y
Megapodiidae	Mound building birds		Y				Y	Y	Y		Y
Meliphagidae	Honeyeater birds					Y	Y	Y	Y	Y	Y
Paradisaeidae	Birds-of-paradise						Y	Y			Y
Petauridae	Possums							Y			Y
Phasianidae	Pheasants	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Picidae	Woodpeckers	Y	Y	Y	Y	Y	Y			Y	
Cacatuidae	Cockatoos						Y	Y	Y	Y	Y
Pteropodidae	Megabats	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sciuridae	Squirrels	Y	Y	Y	Y	Y	Y			Y	Y
Cercopithecidae	Old world monkeys	Y	Y	Y	Y	Y	Y		Y	Y	
Ursidae	Bears	Y	Y	Y							

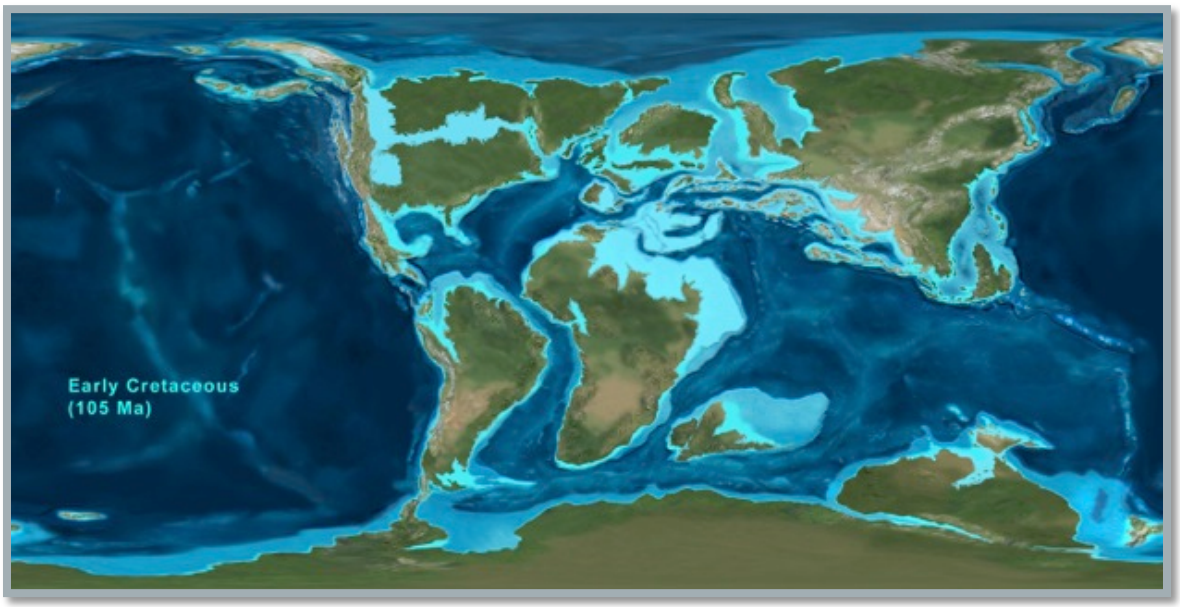

KEY
A – Cacatuidae
B – Cercopithecidae
C – Felidae
D – Macropodidae
E – Megapodiidae
F – Meliphagidae
G – Paradisaeidae
H – Picidae
I – Ursidae
J – Petauridae
Pacific Ocean
NEW GUINEA
AUSTRALIA
MINDANAO
SULAWESI
BURU
CERAM
TIMOR
FLORES
SUMBA
BORNEO
JAVA
South China Sea
ASIA
MALAY PENINSULA
SUMATRA
Indian Ocean
Boundary
(aka the Wallace Line)
0
miles
500

CONTINENTS MOVE OVER TIME

Earth's continents are in constant movement because of plate tectonics. Although the movements are slow, the continents have moved vast distances over periods of millions of years. The maps below show reconstructions of Earth's surface over the last 105 million years. Notice how Australia and its islands were once separated from Asia by an ocean as wide as the modern Atlantic.




Early Eocene
(50 Ma)


Early Cretaceous
(105 Ma)

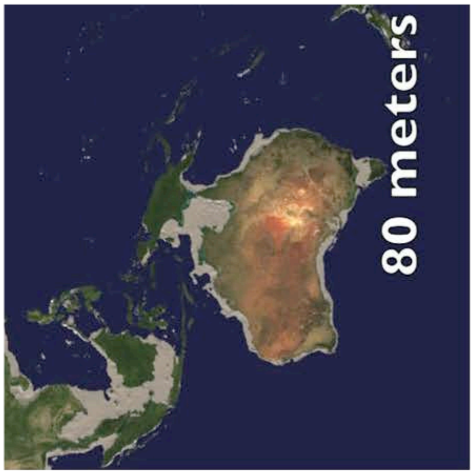
CHANGES IN SEA LEVEL

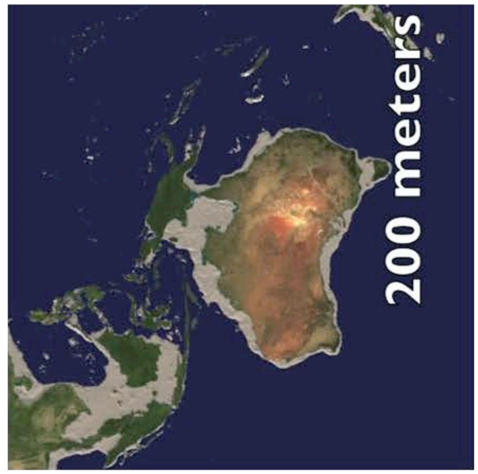
The following figures show how the shape of land changes as sea level changes. The gray areas around continents and islands represent the area that would be exposed as land if the sea level were to drop the amount indicated on the maps.

Sea level fluctuates based on the amount of water that is contained in ice; the amount of ice has increased and decreased throughout geologic history. When the volume of ice is high, sea level is low because the water is trapped in the ice. Conversely, when the ice melts, sea level rises. The last ice age was about 20,000 years ago, and sea levels may have been as much as 200 meters below what they are today.

Using a map of underwater depth, scientists can reconstruct what the continents looked like during the last ice age when sea level was much lower.

Teaching Note: We can now draw the Wallace Line and see that islands to the north and west were attached to Asia, thus accounting for the Asian animals found there, while islands to the east were joined with Australia, although some remained isolated.





Maps courtesy of NOAA