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2007: Exploring the Inner Space of the Celebes Sea

Do You Have the Key?

Focus
Classification and dichotomous keys

Grade Level
5-6 (Life Science/Physical Science)

Focus Question
How can scientists identify organisms they have never seen before?

Learning Objectives
Students will be able to use a dichotomous key to classify a collection of objects.

Students will be able to construct a dichotomous key for a collection of organisms or other objects.

Materials
- ❐ Copies of "Dichotomous Key Worksheet" and "Table 1," one copy for each student or student group
- ❐ (Optional) Examples of dichotomous keys (see "Other Links and Resources")

Audio/Visual Materials
None

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Classroom style or groups of 3-4 students

Maximum Number of Students
30

Key Words
Classification
Taxonomy
Celebes Sea
Dichotomous key
Hands-on

Background Information
Indonesia is well-known as one of Earth's major centers of biodiversity. Although Indonesia covers only 1.3 percent of Earth's land surface, it includes:

- 10 percent of the world's flowering plant species;
- 12 percent of the world's mammal species;
- 16 percent of all reptile and amphibian species; and
- 17 percent of the world's bird species.

In addition, together with the Philippines and Great Barrier Reef, this region has more species of fishes, corals, mollusks, and crustaceans than any other location on Earth.

What, exactly, is meant by biodiversity, and why is it important? The term "biodiversity" is usually understood to include variety at several levels:

- variety of ecosystems: high biodiversity suggests many different ecosystems in a given area;
- variety of species: high biodiversity suggests many different species in a given area;
- variety of interactions between species; and
- variety within species (genetic diversity): high biodiversity suggests a relatively high level of

genetic variety among individuals of the same species.

A simple definition of biodiversity could be "The variety of all forms of life, ranging in scale from genes to species to ecosystems."

Biodiversity is important to humans because our survival depends upon many other species and ecosystems. Some examples of our dependence on biodiversity include:

- fresh air containing oxygen;
- clean water;
- productive soils;
- food, medicines and natural products;
- natural resources that provide the basis for human economies; and
- natural beauty that improves our quality of life.

(adapted from the Biodiversity Project, http://www.biodiversityproject.org/bdimportant.htm)

Quite a lot is known about Indonesia's terrestrial and shallow-water ecosystems. But scientific knowledge and understanding of midwater ocean communities is generally sketchy, and many midwater animals have not been studied at all—even though the midwater ocean environment is our planet's largest ecosystem. Midwater animals range from microscopic zooplankton to the largest animals on Earth, provide a major source of nutrition for benthic (bottom) communities, and are an important link in the transfer of energy and materials from the top to the bottom of the ocean. Note that the term "midwater" as used here includes the entire water column, but the same term has also been used to refer to only part of the water column. Scientists often divide the ocean water column into three zones: the "epipelagic zone" (also called the "sunlit" or "euphotic" zone) from the surface to a depth of about 200 m; the "mesopelagic zone" between 200 m and 1100 m; and the "bathypelagic zone," which is deeper than 1100 m.

The 2007: Exploring the Inner Space of the Celebes Sea Expedition is focused on exploring the variety of midwater organisms in the most biologically-diverse region on Earth. Key expedition questions include:

- What animals are found in Indonesian midwater communities?
- How does the biodiversity of Indonesian midwater communities compare with other marine communities in this region, and with other midwater communities in other regions?
- What proportion of animal species in Indonesian midwater communities is endemic to this region (found nowhere else on Earth), and how does this degree of endemism compare with that of other regions?

Field biologists often use identification guides known as "dichotomous keys" to help them find the correct name for an unknown organism (or to help them decide that the organism is new to science!). A dichotomous key consists of a series of paired statements called "couplets." Each statement in a couplet offers an alternative description of certain characteristics of an organism or group of organisms. The idea is to choose the statement that best fits the unknown organism, and then go to another couplet until the name of the organism is found. Table 1 is a dichotomous key for the objects shown on the "Dichotomous Key Worksheet." There could be many ways to classify these objects; the key in Table 1 could begin by separating "round" and "sharp" objects, for example. The general idea is to begin with broad characteristics and progress to more specific features. Notice that it is very important to work through the couplets in order. Statements 6a and 10a are identical, but they refer to different objects because of the preceding couplets.

This lesson introduces students to the construction and use of dichotomous keys. Using keys is a much more efficient approach to identify organisms than simply memorizing names, because keys help draw attention to features that can be used to distinguish different organisms. Sometimes you may see references to an "artificial key." This simply means that the features described in the key are not the same features used to formally classify the organism into a particular genus and species. The key will still work, even if it is "artificial!" Like many things, using keys takes practice, and the time needed to identify organisms becomes much shorter as students become more familiar with the process.

Learning Procedure

1. To prepare for this lesson, review the introductory essays for the 2007: Exploring the Inner Space of the Celebes Sea Expedition at http://oceanexplorer.noaa.gov/explorations/07philippines/.

2. Briefly introduce the 2007: Exploring the Inner Space of the Celebes Sea Expedition, highlighting the Expedition's emphasis on midwater communities and the fact that these communities have not been well-explored, even though they are part of Earth's largest ecosystem. Ask students how they think scientists identify organisms they haven't seen before. Many students assume that scientists are "super smart" and already know the names of everything they are likely to collect. Introduce the idea of dichotomous keys.

3. Give each student or student group a copy of "Dichotomous Key Worksheet," and have them identify the appropriate letter name for each object using the dichotomous key in Table 1. This is a "troubleshooting" exercise to identify points of confusion or misunderstandings. Be sure students understand that dichotomous keys can be constructed for collections of non-living things as well as biological organisms (e.g., soils, rocks, stamps, stars, recipes).

4. Tell students that their assignment is to construct a dichotomous key to a collection of objects. Alternatively, you can have them classify all the students in their class or working group. Be sure students understand that characteristics used in the couplets should be permanent. If they are classifying each other, clothing color or hair length would not be good characteristics because these features could change from day to day.

5. (Optional) Have students use dichotomous keys to identify shells, insects, plants, or other organisms. These may be organisms found in your community, or in collections available to your students (e.g., museums), or in collections made by students themselves. A keyword search using "dichotomous key" and "student" will locate many suitable resources.

The Bridge Connection

www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Ocean Science Topics," then "Biology," then "Biodiversity" for links to information and activities about biodiversity and classification.

The "Me" Connection

Have students write a brief essay describing how they could use a dichotomous key to classify a real or imaginary personal collection.

Connections to Other Subjects

Language Arts

Assessment

Worksheets, dichotomous keys constructed in Step 4, and discussions provide opportunities for assessment.

Extensions

1. Visit oceanexplorer.noaa.gov to keep up to date with the latest 2007: Exploring the Inner Space of the Celebes Sea Expedition discoveries, and to find out what researchers are learning.

2. See "How to Construct and Use a Dichotomous Key" by Stephen L. Timme (http://www.zoo.utoronto.ca/able/volumes/vol-12/7-timme.pdf) for more activities and ideas.

Multimedia Learning Objects

http://www.learningdemo.com/noaa/ – Click on the links to Lessons 8 and 12 for interactive multimedia presentations and Learning Activities on Ocean Currents and Food, Water, and Medicine from the Sea.

Other Relevant Lesson Plans from the Ocean Exploration Program

Journey to the Unknown & Why Do We Explore [http://www.oceanexplorer.noaa.gov/explorations/02galapagos/background/education/media/gal_gr5_6_l1.pdf] (10 pages, 596k) (from the 2002 Galapagos Rift Expedition)

Focus: Ocean Exploration

In this activity, students will experience the excitement of discovery and problem-solving to learn about organisms that live in extreme environments in the deep ocean and come to understand the importance of ocean exploration.

Cool Lights [http://www.oceanexplorer.noaa.gov/explorations/04deepscope/background/edu/media/CoolLights.pdf] (PDF, 220Kb) (from the 2004 Operation Deep Scope Expedition)

Focus: Light-producing processes and organisms in deep-sea environments

In this activity, students compare and contrast chemiluminescence, bioluminescence, fluorescence, and phosphorescence. Given observations on materials that emit light under certain conditions, students infer whether the light-producing process is chemiluminescence, fluorescence, or phosphorescence. Students explain three ways in which the ability to produce light may be useful to deep-sea organisms and explain how scientists may be able to use light-producing processes in deep-sea organisms to obtain new observations of these organisms.

Jelly Critters [http://www.oceanexplorer.noaa.gov/explorations/05arctic/background/edu/media/arctic05_jellycritters.pdf] (5 pages, 269k) (from the Hidden Ocean, Arctic 2005 Expedition)

Focus: Gelatinous zooplankton in the Canada Basin (Life Science)

In this activity, students will be able to compare and contrast at least three different groups of organisms that are included in gelatinous zooplankton, describe how gelatinous zooplankton fit into marine food webs, and explain how inadequate information about an organism may lead to that organism being perceived as insignificant.

Now You See Me, Now You Don't [http://www.oceanexplorer.noaa.gov/explorations/05deepscope/background/edu/media/now_u_see_me.pdf] (5 pages, 281Kb) (from the Operation Deep Scope 2005 Expedition)

Focus (Life Science) Light, color, and camouflage in the deep ocean.

In this activity, students will be able to explain light in terms of electromagnetic waves, and explain the relationship between color and wavelength; compare and contrast color related to wavelength with color perceived by biological vision systems; and explain how color and light may be important to deep-sea organisms, even under conditions of near-total darkness. Students will also be able to predict the perceived color of objects when illuminated by light of certain wavelengths.

Twisted Vision [http://www.oceanexplorer.noaa.gov/explorations/05deepscope/background/edu/media/twisted.pdf] (7 pages, 303Kb) (from the Operation Deep Scope 2005 Expedition)

Focus (Life Science/Physical Science) Polarization vision.

Students will be able to explain the meaning of polarized light, and will be able to identify three ways in which unpolarized light can become polarized; explain why some animals have polarization vision, and why humans do not have this ability; and discuss three ways in which polarization vision may be useful to marine organisms.

Other Links and Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov – Web site for NOAA's Ocean Exploration program

http://oceanexplorer.noaa.gov/gallery/livingocean/livingocean_coral.html – Ocean Explorer photograph gallery

http://www.zoo.utoronto.ca/able/volumes/vol-12/7-timme.pdf – "How to Construct and Use a Dichotomous Key" by Stephen L. Timme, from Goldman, C. A. (ed). 1991. Tested studies for laboratory teaching.12:101-110. Proceedings of the 12th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 218 pages.

http://www.lamer.lsu.edu/classroom/edonahalfshell/dicotkey2.htm – Creating a dichotomous key to identify fossil oyster shells.

http://www.environmentaleducationohio.org/VirtualTour/TeachingTools/AnimalClassification/skullkey.pdf – A dichotomous key to mammal skulls of Southwest Ohio

http://www.clemson.edu/SCLife/lesson%20plans/adult%20insects/student%20handout%20_terr.insects_.pdf – Dichotomous Key for Adult Insects

http://www.clemson.edu/SCLife/lesson%20plans/aquatic%20insects/student%20handout%202%20-%20aquatic%20insects.pdf – Dichotomous Key for Aquatic Insects

http://www.msc.ucla.edu/oceanglobe/pdf/PlanktonPDFs/PlanktonEntirePackage.pdf – Plankton lesson plans from the University of California, Los Angeles Marine Science Center

http://www.msc.ucla.edu/oceanglobe/pdf/guide_plankton1.pdf – "A Guide to the Marine Plankton of Southern California" by Robert Perry

http://www.marine.usf.edu/pjocean/packets/f01/f01u6p2.pdf – Plankton unit from UCLA's Project Oceanography Science Standards with Integrative Marine Science (SSWIMS)

http://sealevel.jpl.nasa.gov/education/activities/ts3ssac3.pdf – Plankton identification activity from NASA's "Visit to an Ocean Planet" CD-ROM

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard E: Science and Technology

- Understandings about science & technology

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 4.
The ocean makes Earth habitable.

Fundamental Concept a. Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.

Essential Principle 5.
The ocean supports a great diversity of life and ecosystems.

Fundamental Concept a. Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.

Fundamental Concept b. Most life in the ocean exists as microbes. Microbes are the most important primary producers in the ocean. Not only are they the most abundant life form in the ocean, they have extremely fast growth rates and life cycles.

Fundamental Concept d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

Fundamental Concept e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Essential Principle 6.
The ocean and humans are inextricably interconnected.

Fundamental Concept a. The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. It moderates the Earth's climate, influences our weather, and affects human health.

Essential Principle 7.
The ocean is largely unexplored.

Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Fundamental Concept e. Use of mathematical models is now an essential part of ocean sciences. Models help us understand the complexity of the ocean and of its interaction with Earth's climate. They process observations and help describe the interactions among systems.

Send Us Your Feedback

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Please send your comments to:
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Dichotomous Key Worksheet

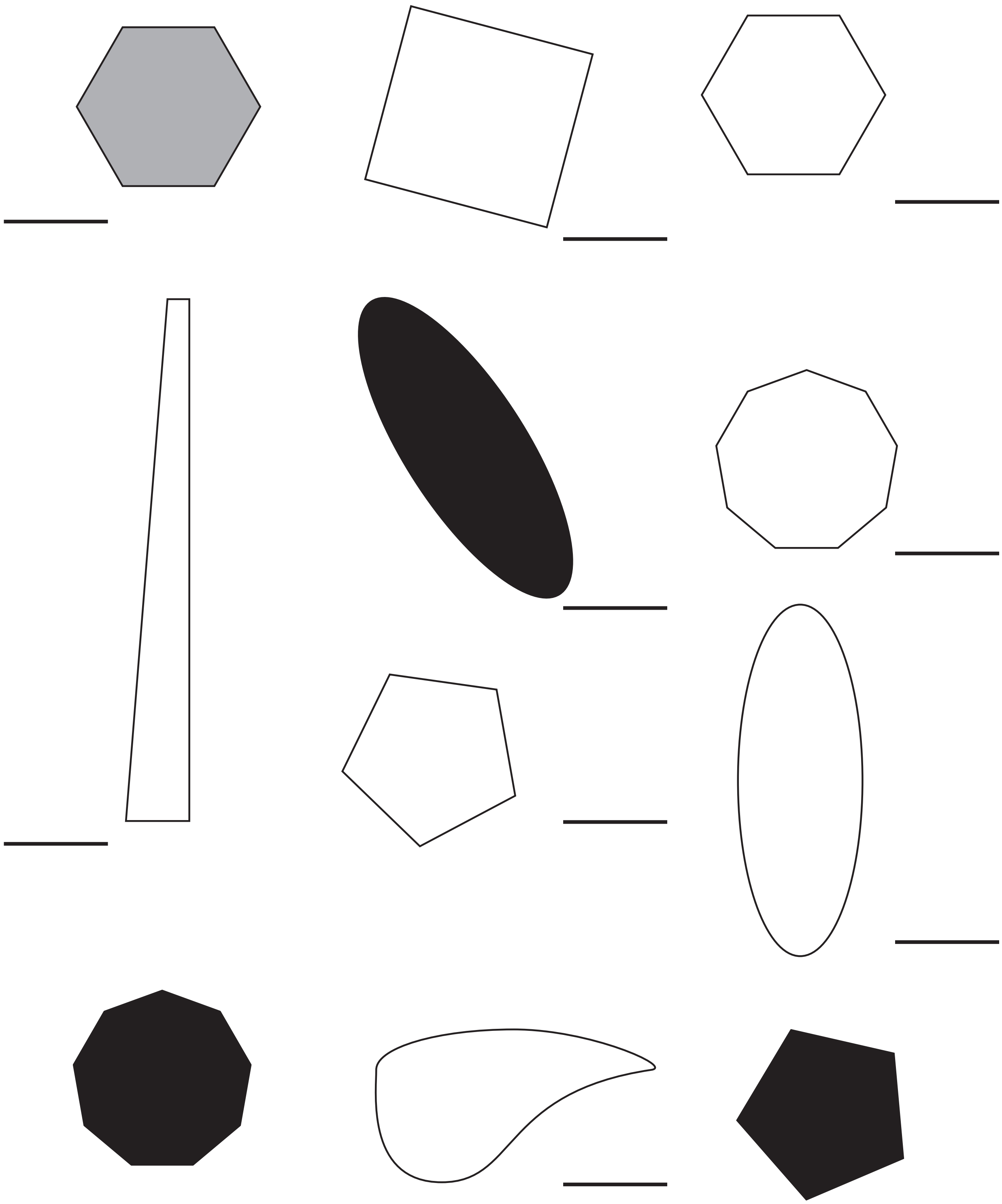

Table 1
A Dichotomous Key to Some Geometric Objects

1a. Objects white inside – 2
1b. Objects not white inside – 8

2a. Objects with all sharp corners – 3
2b. Objects with at least one rounded corner – 5

3a. Objects with four sides – 4
3b. Objects with more than four sides – 6

4a. Four-sided object nearly square – Object B
4b. Four-seded object much longer in one dimension – Object E

5a. Object oval, with no sharp corners – Object J
5b. Object with rounded corners and at least one sharp corner – Object K

6a. Object with five sides – Object I
6b. Object with six or more sides – 7

7a. Object with six sides – Object D
7b. Object with nine sides – Object C

8a. Object gray inside – Object A
8b. Object black inside – 9

9a. Object with rounded corners – Object F
9b. Object with sharp corners – 10

10a. Object with five sides – Object H
10b. Object with nine sides – Object G

Answers to Dichotomous Key Worksheet