ADAPTATION TO LIFE IN A CAVE: FISH ACTIVITY

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For the Virtual Center for the Environment (VCE)
A part of the Institute of Natural Resources Analysis and Management (INRAM)

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TEACHER INFORMATION

ABSTRACT: As animals adapt to life in a cave they change structurally and how they function. This graphing activity will focus on research on Amblyopsid fish done by Thomas L. Poulson and published in the October, 1963, The American Midland Naturalist. Poulson's work is considered a classic on cave adaptation. This research looks at closely related fish, one that live outside of caves, one that lives in springs and cave entrances, and three that live inside of caves. Poulson compares the structural and functional characteristics that organisms need to adapt to life in caves. In the activity students will be given seven sets of Poulson's data and asked to graph the data and compare the organism living outside of the cave to the organisms living inside of the cave. These comparisons are not only found in Amblyopsid fish but are generally characteristic of other cave organisms as reported by Poulson and White (1969) and Culver (1982).

GRADE LEVEL (S): 7--12

OBJECTIVES: Students will:

- Develop a graph format, and graph the data about the age range of the first reproduction, average metabolic rate, weight loss due to starvation, the size of the eye, the number of tactile receptors, and the amount of pigmentation.
- Compare the six characteristics mentioned in the previous objective in five related fish.
- Hypothesize about how living in a cave has affected these six characteristics.

NATIONAL STANDARDS:

Unifying Concepts and Processes
- Evidence, models, and explanation (5-12)
- Change, consistency, and measurement (5-12)

Science as Inquiry – Development of:
- Abilities necessary to do scientific inquiry (5-12)
- Understandings about scientific inquiry (5-12)

Life Science – Development of an understanding of:
- Diversity and adaptations of organisms (5-8)
- Biological evolution (9-12)

NEW MEXICO STANDARDS:

Strand I: Scientific Thinking and Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.

5-8 Benchmark I:	Use scientific methods to develop questions, design and conduct experiments using appropriate technologies, analyze and evaluate results, make predictions, and communicate findings.
9-12 Benchmark I:	Use accepted scientific methods to collect, analyze, and interpret data and observations and to design and conduct scientific investigations and communicate results.
5-8 Benchmark II:	Understand the processes of scientific investigation and how scientific inquiry results in scientific knowledge.
9-12 Benchmark II:	Understand that scientific processes produce scientific knowledge that is continually evaluated, validated, revised, or rejected.
5-8 Benchmark III:	Use mathematical ideas, tools, and techniques to understand scientific knowledge.
9-12 Benchmark III:	Use mathematical concepts, principles, and expressions to analyze data, develop models, understand patterns and relationships, evaluate findings, and draw conclusions.

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments.

5-8 Benchmark I:	Explain the diverse structures and functions of living things and the complex relationships between living things and their environments.
9-12 Benchmark I:	Understand how the survival of species depends on biodiversity and on complex interactions, including the cycling of matter and the flow of energy.

MATERIALS:

- Characteristics of Amblyosid Fish chart
- Colored pencils
- Graph paper

BACKGROUND: Amblyopsid fish are native to North America and are primarily cave dwellers. Poulson (1963) feels that the Amblyopsid fish are preadapted to life in caves because the surface species are nocturnal. *Chologaster cornuta* lives in streams and swamps where it feeds at night and is inactive during the day. *Chologaster agassizia* is commonly found in springs where it is active at night and retreats underground during the day. *Typhlichthys subterraneus* is called the southern cavefish, although its distribution overlaps the more northern species. *Typhlichthys subterraneus* is the most widely distributed of the North American cavefish, and it is found in caves with high water tables where there may be no free air. *Amblyopsis spelaea* is called the northern cavefish where it is found in cave streams south of the maximum extent of glaciation in the midwest during the last ice age. *Amblyopsis rosae* is called the Ozark cavefish where it is found in small cave streams.

The fish compared by Poulson (1963) were within the length range of 43mm to 47mm with the average being 45mm. Four activities and metabolic rate characteristics will be compared in these fish: the average age of the first reproduction of the fish, the size of the fish ova or eggs, and the standard metabolic rate in oxygen used per hour was based on the lowest of five respirometer samples. Metabolism was also compared by calculating the percentage of original weight left after twenty days of starvation.

Three morphological characteristics will also be compared in fish with the same standard length range: the average vertical diameter of the eye in millimeters and the number of neuromast tactile receptors found on the head. *Typhlichthys subterraneu* has the largest number of neuromast of the three cave species, but Poulson (1963) considers the arrangement of the neuromast more elaborate in *Amblyopsis spelae* and *Amblyopsis rosae*. The number of pigmented cells or melanophores per $0.175mm^2$ above the pectoral fin is an indication of the amount of coloration that is present. Poulson (1963) notes that *Typhlichthys subterrane* "has only a few less pigmented melanophores than *Chologaster agassizi*, but its melanophores have less melanin and are more dispersed." Poulson (1963) also reports that *Typhlichthys subterrane* and *Chologaster agassizi* from caves will develop more melanin when kept in light, but the young of *Amblyopsis spelae* and *Amblyopsis rosa* lose melanin as they develop, even if they are raised in light.

PROCEDURES:

1. Use the low and high readings to determine the range of the numerical axis of the graph.
2. Graph the seven characteristics on separate graphs. I like to have the fish on the horizontal axis and the characteristics on the vertical axis.
3. The data can be presented as points or in the case of the age range of the first reproduction, as a bar graph. Different colors of pencils can be used for each type of fish.

CONCLUSIONS: Allow the students to draw conclusions from the graphs. What can be concluded about the characteristics and where the fish live? How does the standard metabolic rate relate to the age of first reproduction, the size of the ova and the percentage of original weight after 20 days of starvation? How does the vertical diameter of the eye compare to the number of neuromast? Hypothesize why Typhlichthys subterraneus, *Amblyopsis spelaea*, and Amblyopsis *rosae* vary in their characteristics.

References:

Culver, David C. 1982. Cave Life, Evolution and Ecology. Cambridge, Mass. Harvard University Press

Mohr, Charles E. and Thomas L. Poulson. 1966. The Life of the Cave. New York: McGraw-Hill Book Company

National Research Council. 1996, National Science Education Standards. Washington D.C.: National Academy Press

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Poulson, Thomas L. 1963. Cave Adaptation in Amblyopsid Fishes. The American Midland Naturalist. Vol. 70; No. 2

Poulson,Thomas L and William B. White. 1969. The Cave Environment. Science. Volume 165, Number 3897

Some Characteristics of Amblyopsid Fish
From Poulson (1963)

Chologaster cornuta (C. c,); *Chologaster agassizi* (C. a.); Typhlichthys subterraneus (T. s.)

Amblyopsis spelaea (A. s.); *Amblyopsis rosae* (A. r.)

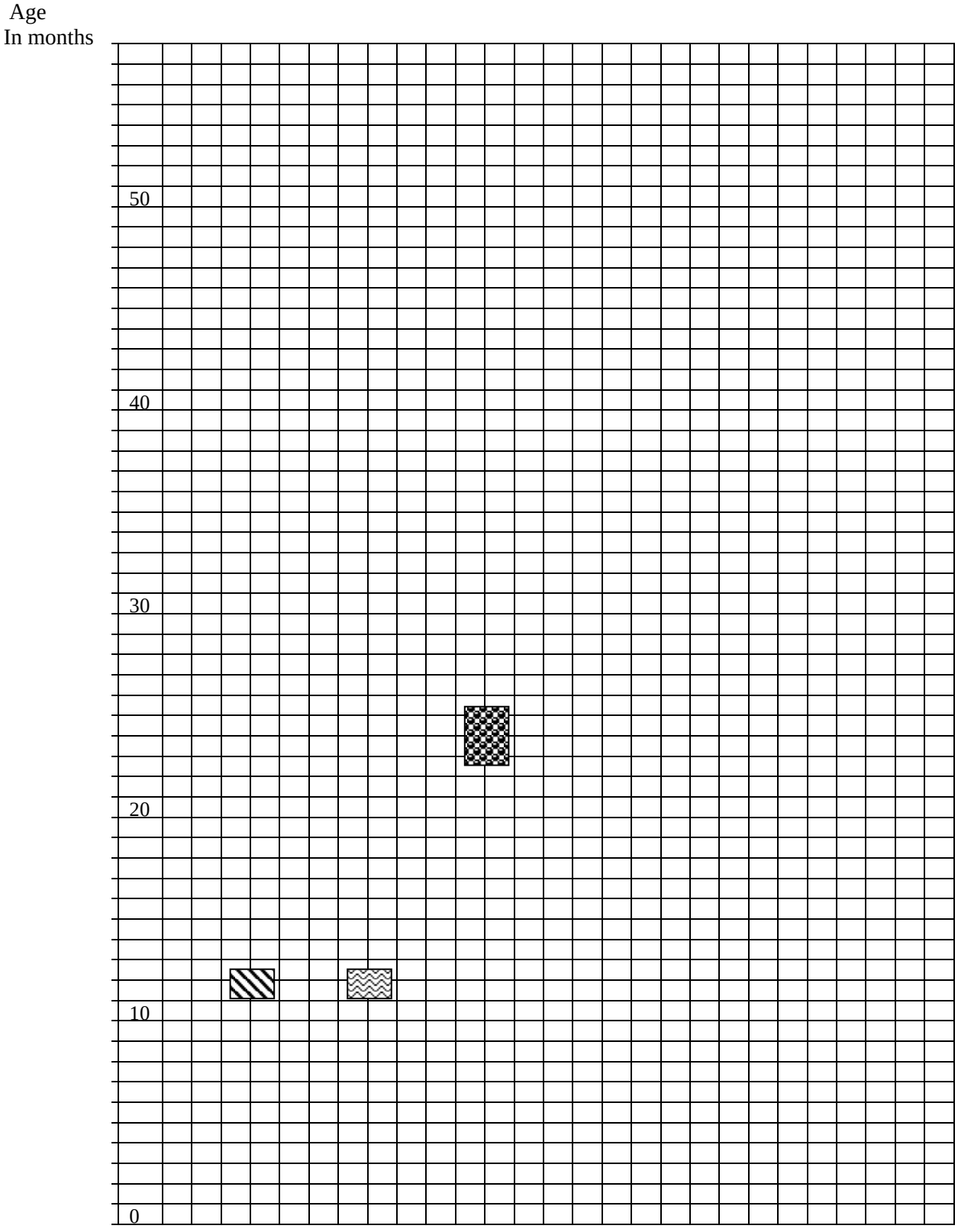
Fish

Characteristics	C. c.	C. a.	T. s.	A. s.	A. r.
Age of First Reproduction; months	11-12	11-12	22-24	36-48	36-48
Size Range of Eggs or Ova: mm	0.9 - 1.2	1.5 - 2.0	2.0 - 2.3	2.0 - 2.3	1.9 - 2.2
Standard Metabolic Rate; O_2/hr	0.0387	0.0277	0.0157	0.0176	0.0107
% of Original Wt. After 20 Days of Starvation	65.8	76.1	85.1	86.7	91.1
Vertical Diameter Of the Eye, mm	1.28	1.08	0.12	0.13	0.08
Number of Neuromast	21.6	28.5	45.6	37.0	32.5
Number of Pigmented Melanophores	103.0	39.5	23.2	9.3	0.5

Thomas L Poulson. 1963. Cave Adaptation in Amblyopsid Fishes. The American Midland Naturalist. Vol. 70; No. 2

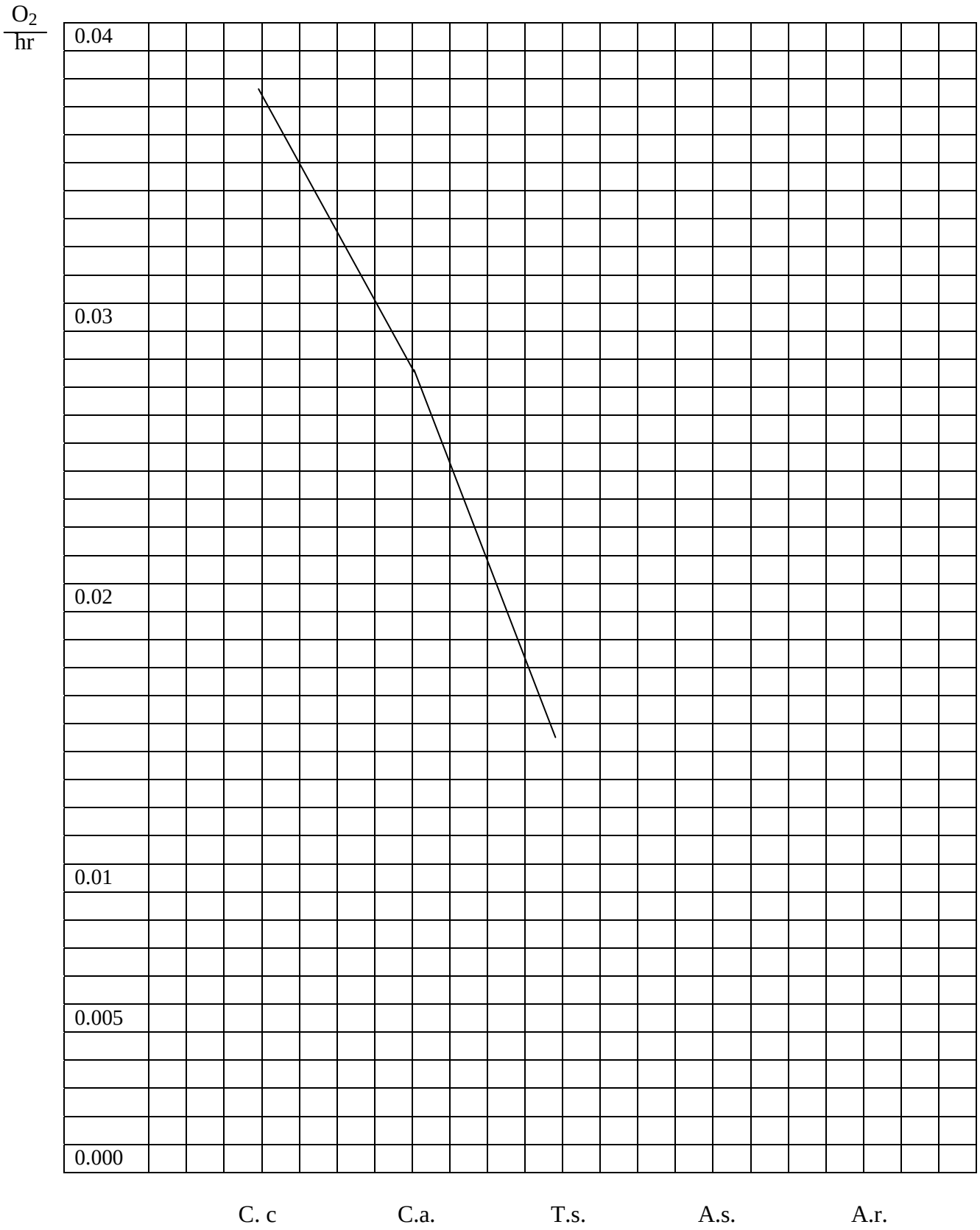
SAMPLES

Average Age of the First reproduction of Amblyopsid Fish



Average Metabolic Rate

of 1 g Amblyopsid Fish



STUDENT ADAPTATION TO LIFE IN A CAVE: FISH ACTIVITY

ADAPTATION TO LIFE IN A CAVE FISH ACTIVITY

Student Name_____

QUESTION: How do related species that live outside and inside of cave compare?
What characteristics might help cave animals adapt to life in a cave?

MATERIALS:

- Characteristics of Amblyosid Fish chart
- Colored pencils
- Graph paper

BACKGROUND: Amblyopsid fish are native to North America and are primarily cave dwellers. Poulson (1963) feels that the Amblyopsid fish are preadapted to life in caves because the surface species are nocturnal. *Chologaster cornuta* lives in streams and swamps where it feeds at night and is inactive during the day. *Chologaster agassizia* is commonly found in springs where it is active at night and retreats underground during the day. *Typhlichthys subterraneus* is called the southern cavefish, although its distribution overlaps the more northern species. *Typhlichthys subterraneus* is the most widely distributed of the North American cavefish and it is found in caves with high water tables where there may be no free air. *Amblyopsis spelaea* is called the northern cavefish where it is found in cave streams south of the maximum extent of glaciation in the midwest during the last ice age. *Amblyopsis rosae* is called the Ozark cavefish where it is found in small cave streams.

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METHODS:

1. Graph the seven characteristics on separate graphs.
2. The data can be presented as points or in the case of the age range of the first reproduction, as a bar graph. Different colors of pencils can be used for each type of fish.

CONCLUSIONS: Continue conclusions on the back if needed

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