"Tales of the Resolution" DRAFT

Mike Passow

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Lesson Plans to Enhance English Language Arts & Literacy in Science Using Graphic Novels

Overview

These educational activities are designed to support mastery of the College and Career Readiness anchor standards identified in the Common Core State Standards for English & Literacy in Science (http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf). We provide sample lesson plans based on "Tales of the Resolution," a series of graphic novels about the *JOIDES Resolution (JR)*, the scientific ocean drilling ship operated by the International Ocean Discovery Program (IODP).

"Tales of the Resolution" are designed by Carl Brenner (Borehole Research Group, Lamont-Doherty Earth Observatory of Columbia University) in collaboration with educators sailing on the *JR*. He creates "Tales of the Resolution" using a commercial program, "Comic Life" (http://plasq.com/ and http://plasq.com/education).

"Tales of the Resolution" are available online through the "JOIDES Resolution" website at http://joidesresolution.org/node/263. Alternatively, they can be accessed through LDEO Borehole Research Group website at http://www.ldeo.columbia.edu/BRG/outreach/media/tales/index.html, or through Earth2Class http://earth2class.org/site/whats-the-role-for-graphic-novels-in-science-education-with-carl-brenner/.

To date, six episodes have been issued.

Episode 1: "Tales of the Resolution" (Oct 2008)
The reader is introduced to the ship and its history of discovery. At that time, the *JR* was about to undergo a major re-fitting after two decades of scientific ocean drilling.

Episode 2: "Re-Fit Madness" (Feb 2009)
The focus of this episode is on the renaissance of the *JR* undertaken in Singapore. It provides a rare description of how science research at sea sometimes requires the re-engineering of the ship itself. Taking on such an effort is possible through the highly coordinated efforts of thousands of scientists, engineers, technicians and other workers.

Episode 3: "Resolution Reloaded" (June 2009)
This episode provides colorful explanations of the *JR*'s drilling and borehole logging operations, lab equipment, range of skills required of personnel aboard the ship and glimpses of life during an expedition.

Episode 4: "Arctic Rainforest" (November 2009)
Read about an expedition in the Pacific that investigated questions about major climate changes during the past 50,000,000 years through the study of carbonate microfossils and borehole logs.

Learn how their sites were selected and why microfossils are important indicators of age and climate change.

Episode 5: "Choose Your Own Tale of the Resolution—Jobs on the *JR*" (June 2011)
The reader can select to follow a scientist, an engineer or a welder through a re-creation of an expedition where a problem that threatened the success of the research was identified and, through their combined skills, successfully solved.

Episode 6: "In Search of Ancient Lava Flows" (April 2012)
Expeditions at sea do not always go as planned, so this Tale relates what happened when the drill became stuck in the ocean bottom. The reader finds out how the staff on the *JR* dealt with this unexpected problem. This episode also focuses on how and why we investigate ancient lava flows.

Ideally, you and your students should begin with Episode 1 and work through them in order to develop a familiarity with the scientific and technological goals. However, much can still be gained reading them individually or in a different sequence.

These Lesson Plans include "Student Pages" with suggested questions and activities to accompany the readings, and "Teacher Pages" with suggested answers to the questions and other information useful for implementing the curriculum. We recognize that you the teacher are the expert on what would work best in your classroom, so feel empowered to modify these Lesson Plans for your situation.

Objectives of the Graphic Novels

1. Scientific ocean drilling retrieves rock and sediment cores that can be used to infer important patterns of climate and Earth events in the geologic past.

2. Geophysical instruments lowered into the hole from which cores have been retrieved can provide additional valuable information about the nature of ocean sediments and Earth's history.

3. Scientists work with engineers and technicians to develop strategies and create instruments necessary to solve problems, even under the extreme conditions of conducting research out at sea.

4. Science and other subjects provide effective formats to help students meet Common Core ELA standards for college and career readiness, reading and writing.

Lesson Objectives

(same for each lesson)

1. To enhance literacy in science

2. To have students answer critical thinking questions and comprehension questions related to each episode of the Tales of Resolution

3. Students will be able to comprehend the scientific graphic novels by answering the questions with 90% accuracy.

Time to accomplish each lesson: 45 minutes to 1 hour
Readings can be also be assigned as out-of-class activities.

Grades: 6th-12th grade and gifted and talented students in 3rd-5th

Science Education and Other Standards

Related NGSS (Next Generation Science Standards), Ocean Literacy Principles and Common Core ELA Standards: See Appendices 1 and 2.

Materials Needed (for each lesson):

- Computer access to Tales of the Resolution graphic novels http://joidesresolution.org/node/263 or http://www.ldeo.columbia.edu/BRG/outreach/media/tales/index.html and other referenced websites.
- Teacher Pages
- Student Pages
- One lesson includes suggestions for enrichment that involve making a model ACORK, but selecting what materials to use is part of the challenge.
- If desired, your school could purchase Comic Life licenses so students can create their own novels. (http://plasq.com/ and http://plasq.com/education).

- Optional: Exit Slips to share what they learned. SAMPLE:

What I enjoyed most from reading this episode was
Two questions I have are

Optional Pre-requisites:

JR Playing Cards

http://oceanleadership.org/education/deep-earth-academy/educators/classroom-activities/grades-5-8/jr-playing-cards/

Extensions:

Have students write down follow-up questions for other students to answer

Have students write down questions they would like to ask the characters/people in the episode

HardCORE Writing

http://oceanleadership.org/education/deep-earth-academy/educators/classroom-activities/grades-5-8/hardcore-writing-leg-171-pencil/

Careers at Sea: Cinducting Science on the JR

http://oceanleadership.org/education/deep-earth-academy/educators/classroom-activities/grades-5-8/careers-at-sea-conducting-science-on-the-joides-resolution/

Appendix 1. Selected Pertinent NGSS and Science Literacy Principles

The *Tales of the Resolution* episodes and suggested reading questions are aligned with the following standards and principles:

NGSS (Next Generation Science Standards)

Performance expectations

MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6 billion-year-old history.

MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

MS-ESS2-3: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

Applicable NRC Framework Elements:

Science and Engineering Practices

Analyzing and interpreting data

Developing and Using Models

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Connections to Nature of Science

Scientific Knowledge Is Based on Empirical Evidence

Disciplinary Core Ideas

ESS1C: The History of Planet Earth

ESS2.A: Earth Materials and Systems

ESS2.B: Plate Tectonics and Large-Scale System Interactions

ESS2.D: Weather and Climate

ESS2.E: Biogeology

ESS3.d: Global Climate Change

PS4.1: Wave Properties

ETS1.b: Designing Solutions to Engineering Problems

Crosscutting Concepts

Patterns

Empirical evidence is needed to identify patterns.

Scale, Proportion, and Quantity

Patterns observable in one scale may not be observable or exit at other scales.

Stability and Change

Change and rates of change can be quantified and modeled over very short or very long periods of time.

Interdependence of Science, Engineering, and Technology

Science and engineering complement each other in the cycle known as research and development. Many R & D projects may involve scientists, engineers, and others with wide ranges of expertise.

Earth Science Literacy Principles

- Big Idea 1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet,
- Big Idea 3. Earth is a complex system of interacting rock, water, air, and life.
- Big Idea 4. Earth is continuously changing.
- Big Idea 6. Life evolves on a dynamic Earth and continuously modifies Earth.

Ocean Literacy Essential Principles

- Principle 1: Earth has one big ocean with many features.
- Principle 2: The ocean and life in the ocean shape the features of Earth.
- Principle 7: The ocean is largely unexplored.

Climate Literacy: The Essential Principles of Climate Science

- Principle 4: Climate varies over space and time through both natural and man-made processes.
- Principle 5: Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
- Principle 7: Climate change will have consequences for the Earth System and human lives.

Appendix 2

Reading Standards for Literacy in Science and Technical Subjects 6–12
http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf
Use *Tales of the Resolution* episodes and reading questions to address these standards:

Key Ideas and Details
1. Cite specific textual evidence to support analysis of science and technical texts.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements or performing technical tasks.

Craft and Structure
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grade-appropriate texts and topics
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

Integration of Knowledge and ideas
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Range of Reading and Level of text Complexity
10. Read and comprehend science/technical texts in the grade-appropriate text complexity band independently and proficiently.

Use "Tales of the Resolution" episodes and questions to address these standards:

College and Career Readiness Anchor Standards for Writing

[See http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf, pp. 63 – 66 for more details.]

The grades 6–12 standards define what students should understand and be able to do by the end of each grade span. They correspond to the College and Career Readiness (CCR) anchor standards below by number. The CCR and grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Text Types and Purposes
1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences.

Production and Distribution of Writing
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Research to Build and Present Knowledge
7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

Range of Writing
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

Teacher Page: Episode 1

Answers are in italics

Lesson Plan for Episode 1 "Tales of the Resolution" (http://joidesresolution.org/node/3309)

After reading the episode, either in a screen or print version, students demonstrate their understanding by answering reading comprehension questions. The following sample questions can be modified based on academic level and learning styles of individual classes and students.

1. What are three important reasons for operating the *JR* and other drilling platform ships?
1. To explore earth's history and structure
2. To drill into the seafloor for core samples
3. To cut core samples into sections for study

2. Four steps in collecting seafloor materials include:
W) A cylinder of mud or rock (core) fills the drill pipe in 9.5 m (30-ft.) sections
X) Cores are brought up to the ship and prepared for study.
Y) Rotating cones on the bit rotate as the drill string rotates
Z) The drill bit is lowered to the seafloor on the end of a drill string

   What sequence of letters represent the correct order of these steps?__*ZYWX*________

3. What kind of information can be discovered by borehole logging that adds to what is learned from the cores?
   (A) Identification of fish and other seafloor organisms

   (B) Measurements of earthquakes on the ocean floor

   (C) Physical characteristics of the sediments or rocks that were cored

   (D) Samples of the seawater for chemical testing in shipboard laboratories

4. How long has ocean drilling for earth science research been conducted?
   ___*40 years*________

5. What do scientists call the data collected from specialized tools sent down the borehole?
   ____*logs*______

- Use the sample "exit slip" to share what they learned.

Teacher Page: Episode 2

Answers are in italics

Lesson Plan for Episode 2 "Re-Fit Madness"

After reading the episode, either in a screen or print version, students demonstrate their understanding by answering reading comprehension questions. The following sample questions can be modified based on academic level and learning styles of individual classes and students.

1. During its first 20 years of exploration, the *JOIDES Resolution* made many discoveries. Some of these are included in an online activity called "Treasure Chest of Cores" (http://joidesresolution.org/node/273).

Select one or more of these and explain their importance in deciphering Earth's history.

Answers for each core sample option:

Leg 171: This core shows the impact of an asteroid hitting earth 65 mya and the micro-organisms that went extinct at that time. It is important for understanding what animal lineages existed and evolved into current life forms.

Leg 158: This core shows that hydrothermal ores are deposited both above and below sediments. This is important for analyzing sediment data and earth's history.

Leg 183: This core shows land crust found in the middle of the Indian Ocean surrounded by volcanic rock. This is important because it tells us that a piece of a continent broke off and was covered by volcanic lava flows and then covered by ocean. It shows a historical event.

Leg 208: This core shows 2 very distinct physical properties that show evidence for a massive, quick warming event with release of gases from the ocean. It is important as a major historical event on earth that affected life. Could this happen again then since it happened in the past?

Leg 165: The physical changes across this core support that climate change initiating in Greenland affected the tropical regions of Venezuela. It is important because it teaches that tropical areas have a correlation to climate change.

Leg 169: This core shows a large copper deposit. It was the first one found of this size and was important to learning how copper mineralizes and helping the mining industry on land.

2. Match each part of the *JOIDES Resolution* with what happens in that location.

A. Accommodations	1. Area in the rear of the ship where helicopters can land and take off
B. Bridge	2. Bottom of the ship that floats in the water
C. Derrick	3. Captain and crew control the ship, science operations are planned
D. Helipad	4. Kitchen and dining area

E. Hull
F. Labstack
G. Mess and galley

5. Multi-story structure that contains the scientific laboratories
6. Rooms where crew and scientists sleep
7. Tower-like structure that can lift and position the drill string

Answers:
1. D.
2. E.
3. B.
4. G.
5. F.
6. A.
7. C.

3. Re-fitting the JR involved many steps that had to be carried out in an organized order. Below is an alphabetical list of 18 important steps. Read the episode and make notes to learn what happened during the re-fitting. Use the list below to show the sequence of events by listing each step's letter in the correct order in the table. Give a reason why each step had to happen before the next step.

   (Note: If appropriate for your students, shorten the list to 10, 8, or fewer steps.)

A. Barnacles and other materials were sandblasted off the hull
B. Construction within bridge, lab modules, and offices
C. Demolition of the bridge and removal of the bridge module.
D. Demolition of the lab and removal of the lab stack
E. Installation of computer network
F. Installation of electrical and computer network cables
G. Leaving the shipyard dry-dock for sea trials
H. New accommodation quarters were constructed below the main deck
I. New bridge constructed and installed
J. New deck was installed.
K. New galley and mess
L. New lab stack constructed and installed
M. Placement of new lifeboats
N. Propellers were removed, cleaned, and reassembled
O. Removal of the derrick
P. Replacement of the refurbished derrick
Q. The hull was completely repainted
R. Towing into the dry dock.

Step	Letter	Reason this step goes before the next step
1	*O.*	*The derrick, the largest body on the ship, had to be removed first for refurbishing before any other demolition began because it was in the way.*

2	*D.*	*Demolition of the labs took place next in preparation for removing them from the ship entirely. The derrick had set between here and the bridge.*
3	*C.*	*Demolition of the bridge was next as it was on the other side of the derrick.*
4	*P.*	*The refurbished derrick was replaced to then pull the ship into the dry dock.*
5	*R.*	*It was then towed into the dry dock.*
6	*A.*	*Materials were sand-blasted off of the hull because the water was drained at the dry dock to access the hull.*
7	*N.*	*Being dry and accessible, the propellers were transported to shore and cleaned.*
8	*Q.*	*The hull was repainted while the propellers were off and cleaned.*
9	*H.*	*New accommodations were installed below deck after the demolition in there.*
10	*J.*	*A new deck was installed in pieces over finished accommodations and next to the bridge.*
11	*L.*	*New labs were put in on other side of derrick above deck.*
12	*I.*	*A new bridge was put in after the accommodations underneath were finished.*

13	*F.*	*Installation of electrical lines now that walls were in place.*
14	*E.*	*Installation of computer network now that cables were in.*
15	*B.*	*Construction within the bridges and labs took place because it is inside of the larger structures*
16	*M.*	*Placement of lifeboats on the outside took place.*
17	*K.*	*New Galley and Mess Hall went in for food on board. You do not want food to spoil during construction.*
18	*G.*	*Ship leaves the dry dock for sea trials to test everything out.*

Use the sample “exit slip” to share what they learned.

Teacher Page: Episode 3

Answers are in italics

Lesson Plan for Episode 3 "Resolution Reloaded "

After reading the episode, either in a screen or print version, students demonstrate their understanding by answering reading comprehension questions. The following can be modified based on academic level and learning styles of individual classes and students.

1. Assessing whether the JR was ready to begin scientific operations after its renovation was a 7-member group. What was the title for this group? What was its acronym? Why do we often use acronyms? *The Readiness Assessement Team (RATS). We use acronyms for note-taking and making it easier to refer to items.*

2. Give two reasons why "outside evaluators" are important in determining the effectiveness of a program. *Outside evaluators will see things that others did not see or for a second set of eyes and brains to catch things that are missed.*

3. Match the job title with the activity:

1. Captain	A. Conducts the scientific investigations
2. Core curator	B. Describes and catalogs every core
3. Engineer	C. Keeps the ship and all equipment working
4. First Mate	D . Manages equipment in the science labs
5. Head of Food services	E. Runs the drilling operations when the ship is on site
6. Lab officer	F. Runs the drilling operations during the other shift
7. Logging staff scientist	G. Supervises the galley and mess
8. Offshore installation manager	H. Sends the instrument string into the hole
9. Scientist	I. Steers the ship so it doesn't crash or run into anything
10. Senior Tool Pusher	J. Steers the ship during the other shift

1. I.
2. B.
3. C.
4. J.
5. G.
6. D.
7. H.

8. E.
9. A.
10. F.

You can find out more about marine careers from the JR website Resources section (http://joidesresolution.org/node/904).

4. How long is each core when it is brought up and carried to the receiving platform?
   9.5 meters

5. What is the length of each segment after the core is cut? Why is it useful to cut it down?
   150 cm. It is cut to this length to store them and move them easily.

6. Learn more about "What Is a Core?"
   Answers will vary.

7. When cores are retrieved, they are first sent through a series of instruments. Complete the table by writing a brief description of what can be measured by each instrument.

Instrument	Physical properties measured by this instrument
Formation Microscanner	*Measures resistance to electrical current, meaning the texture of the sediment is determined- hard to soft.*
P-wave Logger	*Measures how sound waves travel through the core- the harder the core, the faster sound moves through it.*
Digital imaging system	*Takes a photo of the core sample*
Color reflectance system	*Measure the colors of the cores*

8. You can learn more about the value of borehole logging through "It's Not Just the Core that Tells the Hole Story."

- Use the sample "exit slip" to share what they learned.

Writing across the Curriculum

- Imagine you have been selected to write blogs about the expedition.
    - What would you include in a blog about what life is like aboard the JR during your non-working shift?
    - What would you blog about the scientific activities taking place during this expedition?

- Use the information provided in this episode to write what needs to be done to retrieve a core at the selected drilling site. Begin with hoisting the stored pipes into a vertical position, and end with the core being carried to the receiving platform.

Teacher Page: Episode 4

Answers are in italics

Lesson Plan for Episode 4 "Arctic Rainforest"

After reading the episode, either in a screen or print version, students demonstrate their understanding by answering reading comprehension questions. The following can be modified based on academic level and learning styles of individual classes and students.

Examples of suitable questions:

1. In this episode, our planet is described as once being a "Greenhouse World," but now is an "Icehouse World." What do scientists mean by these phrases? What evidence has been found that indicates Earth was much warmer 50 million years ago than it is now?
   In the Greenhouse World, temperatures were much warmer and there were no ice caps at the poles. There were swamp forests full of alligators and tortoises. Evidence: fossils from these creatures have been found in 50-million-year-old rocks. During the Icehouse World, we have ice caps at the poles.
2. What are some kinds of materials scientists try to obtain from sea floor cores to determine past climate conditions? Why are these useful to interpreting ancient climates?
   They collect ocean sediments – these contain a record of past climate conditions.
3. Why did the scientists on this JR expedition choose this particular study area?
   It is rich in sediments that contain a record of climate change over the past 53 million years. Sediments from latitudes closer to Antarctica have moved up towards the equator over time.
4. Whose job is it on a JR expedition to determine the age of the core materials? What do they use to estimate the sediment age?
   Biostratigraphers do this by looking at samples under a microscope to see which species of microfossils are present. By identifying the species present, they can estimate the sediment age.
5. Give a brief explanation of why the older parts of the cores were dark with no calcium carbonate shells, and the younger upper parts were full of carbonate microfossils.
   The carbonite compensation depth changed

   6. Based on the expedition's findings, when did Earth experience a dramatic change from older sediments with no calcium carbonate to young sediments filled with calcium carbonate? What probably happened at that time period?
   At this site about 34 million years ago. Large ice sheets began to develop in Antarctica.

   - You can learn more about the expedition by watching the PEAT News Network at http://joidesresolution.org/node/2110.

   - Use the sample "exit slip" to share what they learned.

Enrichment:

Read about "The Fate of Calcium Carbonate" on the American Chemical Society website:

http://www.melodyshaw.com/files/The_Fate_of_Calcium_Carbonate.pdf

If you try this experiment, write a "lab report" for your teacher in the appropriate style used in your school. As an alternative, follow this style:

Purpose - Give the reasons why you do this and the key questions.
Procedure - State clearly and concisely the steps you followed.
Results - Present what you found in words and, if appropriate, graphs and tables.
Discussion - Explain the meaning of your results and answers to the key questions.
Summary (Conclusion)- Provide a short recap of what you did and found.
Acknowledgements and References - Thank people who helped and cite print and online references used.

Teacher Page: Episode 5

Answers are in italics

Lesson Plan for Episode 5 "Choose Your Own Tale of the Resolution! Jobs on the JR"

This episode uses the choose-your-own story format, so students should try to enjoy it by selecting each pathway consecutively. After reading each story, students should answer questions such as the samples below.

Examples of suitable questions include:

1. An ACORK is a tool system that
   A. floats like a cork on the surface
   B. *penetrates the sediments to collect data from below the seafloor*
   C. rises and falls through the water column
   D. slowly crawls over the sea floor like the Mars rovers

2. What is the purpose of each of these parts? Complete the chart.

Component	**Purpose**
Casing	*Metal pipe that is lowered into the ocean floor to prevent shallow sections of the hole from collapsing*
Cement and bridge plug	*Seals the bottom of the casting, prevents leakage, allows additional instruments to be added*
Data recorder	*Stores pressure and temperature data until they can be downloaded by ROV or submersible.*
Hanger	*Sets the ACORK flush with the seafloor*
Hydraulic umbilical	*Transmits pressures from the formation screens to the seafloor data recorder*
Re-entry cone	*Helps guide the drill string and casing during multiple trips into the hole*
ROV platform	*Where submersibles and ROVs land to collect data and samples*

Screens	*Allow water below the seafloor to reach the sensors while protecting them from sediment*
Well head	*Where additional instruments can be installed*

3. If all goes according to the research design, for how long will the ACORK remain on the sea floor? What are the benefits of conducting research for such a long time period?
   20 years. Get lots of data over time, can be compared to each other and see changes.
4. How, at first, will the data be retrieved? What are longer-term plans to obtain the data? What probable assumptions were made to design the data collection in this way?

Data is retrieved by ROV. Later by a fiber-optic cable, allowing data to be received in offices in real time. Assumptions were made that this fiber optic technology will be available in a few years. And that the ACORK will still be working properly!

Writing across the Curriculum

- Imagine you are one of the people from the JR featured in this episode, and have been invited to talk at a school like yours. Below are sets of questions that the students would like to have answered in your talk. Based on what you read in this episode and other knowledge, what would be your answers to the questions?

➢ Questions for the Scientist:
  What is your area of scientific expertise?
  Why is it helpful to have knowledge from many different subjects?
  What do you hope to learn through this expedition?

➢ Questions for the Welder:
  What do you do in your job on the JR?
  Where did you get the experience needed to land this job?
  How do you keep yourself safe when you are welding?

➢ Questions for the Engineer:
  What is your basic job aboard the JR?
  What did you do before this that helped you do your job on the JR well?
  Why is it important to be very precise in your work?

- This episode focuses on a problem with an important piece of the ACORK. Use the information in this episode to write a report about it to the Ocean Drilling Board of Directors. Here are points to include:
  - ➢ What was the problem?
  - ➢ Why was it important to correct the problem before the ACORK was put in place?

- How as the problem solved by the engineer?
- How was the problem solved by the welder?

Technology Enrichment

You can't make a real ACORK, but you can make a scale model. Use the diagram provided in the episode as your guide. Here are some questions to consider as you work.

1) Trace or photocopy the diagram of the ACORK on page 3. Decide how you should measure the length of each part in the drawing so you will have the same relative size in your model? Be aware that the actual ACORK was over 300 feet (100 m) in length and about 2 ft (0.7 m) in diameter.)
2) What materials will you use to build the model? Describe the advantages and disadvantages of these and other materials?
3) How will you set up the model for display? How will you label the sections?
4) What other information should you include in your finished model to explain what ACORKs can do?

This activity could be presented as a competition among groups in the school, with a "science fair" to share efforts and judge effectiveness.

Teacher Page: Episode 6

Answers are in italics

Lesson Plan for Episode 6: "In Search of Ancient Lava Flows"

After reading the episode, either in a screen or print version, students demonstrate their understanding by answering reading comprehension questions. The following can be modified based on academic level and learning styles of individual classes and students.

Examples of suitable questions:

1. Use a world map to locate the Louisville Seamounts. In what region of the ocean are they found? What is their approximate latitude and longitude? How far away are they from some better-known geographic locations?
   They are in the southwest Pacific Ocean. 61.9 degrees S/157 degrees W, is where they start at one end. They are east of New Zealand.
2. What scientific questions does this expedition seek to answer?
   Is the hotspot making the Louisville Seamounts moving? Did it move the same way the Hawaiian hotspot moved 80-50 million years ago?
3. When did the Chief Scientist first announce his inspiration for this expedition? Why did it take such a long time before he could put to sea?
   When he was first a graduate student! It took a long time for preliminary research and convincing colleagues that it was worth pursuing.
4. What are seamounts? How do they form? What makes seamounts like the Louisville or Hawaii-Emperor seamounts unusual and worth the effort of this expedition?
   Seamounts are mountains in the ocean. They form as volcanoes. They sometimes break through and become islands. These are unusual because their magnetic particles show systematic change over time and that the hotspot forming them may have moved.
5. What evidence are the scientists looking for in recovered lava flows?
   They are looking for the orientation of the magnetic particles – to see if they are all the same or if the angle has changed over time.

6. This Tale focuses on solving problems that can occur while at sea during an expedition. What was the problem that suddenly developed during the drilling and core recovery?
The drill string got stuck!
7.How did the JR engineers and drilling crew finally solve the problem of the stuck drill bit?
They exploded it out!
8.What safety measure did everyone aboard have to take to avoid an accident when the plan for solving the problem was put in place? Why was this necessary?
Turn in their cell phones. This was necessary because they didn't want anything transmitting a signal that could set off the explosive by accident.

9. Did their solution work? What was the next problem the expedition had?
   Yes, it worked. The next problem was the free fall funnel tipping over.
10. What problem was found at the new hole with regard to the original scientific question? What was recovered? Why couldn't these rocks be used to answer the question?
    The cores were breccias and very few lava flows. Breccias are broken fragments of rocks and did not contain the kinds of evidence needed to answer the question about the lava flows.
11. What do sedimentologists study? Petrologists? Alteration petrologists?
    Sedimentologists study the sediments. Petrologists study rocks. Alteration petrologists study changes in the rocks.
12. After the ship finished this expedition at sea, what plans did the scientists have to continue their research on land?
    They would take more samples and study them back in their own labs.