Scientific Models: More than just a pretty face
An Informal Loop

<table>
<tr><td colspan="3">Unifying Concept: Scientific Methodology   Name: Lori Gillam</td></tr>
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<td>Math Standard C: A student should understand and be able to use a variety of problem solving strategies.

Science Standard A1:
Students develop an understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations and defend scientific arguments.

Science GLE: The student demonstrates an understanding of science by [8] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

Multicultural Standard E: Culturally knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interactions of all elements in the world around them.

Science concept: The scientific method is a process people use to understand and predict natural phenomena.

Student Objective:
SWABT
Evaluate the benefits and limitations in the use of models.
Generate conclusions based on their observations.</td>
<td>Process Skills
Questioning
Observing</td>
<td>Materials:
Lab-Aids #100 Ob-scertainer kit

Transparent tape, to tape the black discs closed

Science notebook
Pencil

Attachment for Apply Section: Curse of the Hidden Tomb (key and phrase)</td>
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Gear- Up: Show students a picture of an Egyptian pyramid. Tell students the following story: Some strange black discs were unearthed from an ancient Egyptian tomb. These strange black discs are impervious to x-rays or any other type of technological analysis that would show what the insides look like. Your research team (your lab group) has been asked to help determine what's going on inside the disc. On the wall of the tomb strange inscriptions, in an unrecognizable form of hieroglyphics, were also found. Currently, Archeologists are working to decode this message. As their work progresses, the Archeologists will keep you informed. Rumor has it that if the discs are opened, a terrible curse will be released and present will be doomed. (Domed to relive 8^{th} grade over and over – like "Ground Hogs Day"). Have students pick up a black disc and shake it - what can they figure out? (Students immediately report that there is a marble-like something inside.) What evidence do they have to support this? (From their past experiences, they can tell that whatever is inside is rolling around, thus it has to be like a marble.) What else can they tell about the inside of the black disc? (The marble moves differently in each disc.) What does this mean? (That there are different partitions in each disc.) Researchers should be given enough time to work through 4 discs.	Observing Predicting	

Explore: Remind students that they have been tasked with figuring out what was going on inside the disc. They already know two things: 1. Something is rolling around inside. 2. Something is periodically blocking the free rolling movement of the "marble". They need to focus on the object that is blocking the free roll of the "marble". What could these barriers or partitions look like? That now their task; to determine the pattern of the interior partitions. Procedure: 1. Set up a 4-column data table. Title the 3 columns "number of container", "First Prediction: shape within container"; "Prediction, revisited"; leaving the 4th column temporarily blank. Title the data table, "Ancient Code Containers Data Table". 2. Record the number of the black disc in the first column in your data table. (Found on the bottom, center, of the disc.) 3. Carefully shake and tilt the black disc. The smaller your motions, the better data will be collected. Quick flipping, snapping and tilting motions with the disc will make tracking the ball (mentally) more difficult. 4. From the sound and path of the steel ball, determine the shape and location of the partition or partitions inside the black disc. Try to draw a mental map (or model) of the path of the marble while tilting the disc. In column 2 of your data table, record this data. 5. Test your hypothesis by moving the ball along the partitions according to your hypothesis. If you wish to make changes to your hypothesis or create a new one, do so in the third column. 6. Only fill in the third column when you are reasonably confident with your hypothesis. If time permits, have your lab partner validate your hypothesis 7. Continue testing each black disc. Some are more difficult than others. Do not spend more than 5 minutes on each black disc. Remember: DO NOT open the black disc! Students should be talking to each other, asking for verification and validation of their current model.	Observing Predicting	

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<td>Generalize:
With the students discuss the following questions:
1. How quickly did you make a guess about the inside configuration of the black disc? How certain were you with your first guess?
2. Were all the black discs equally easy/difficult to solve? Are you confident in the models you have established for all of the black discs? Explain.
3. Did you ever ask your lab partner to validate your hypothesis? Did they agree/disagree with your hypothesis? How did that make you feel?
4. When making a hypothesis and/or retesting this information, what were you doing? (developing a theory or model). What does a model do?

A guided discussion, see attached/Resources: Developing Models; general information</td>
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<td>Vocabulary
Hypothesis
Theory
Models
Validation
Verification
Partitions
Dividers
Evidence
Cryptologist
Biased test
Unbiased test
Deciphered

Validation:
To give official confirmation, or approval

Verification:
Evidence that establishes or confirms the accuracy of something</td>
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<td>Apply:
Testing the Key:
A group of Egyptian cryptologists have developed a hypothesis that directly links the black discs to a specific set of ancient hieroglyphics, ones that have never before been deciphered. Their current hypothesis is that these hieroglyphics are some sort of key, and when coupled with the discs will reveal and ancient knowledge: perhaps the location of hidden tomb! It is still feared that there is some kind of curse attached to this tomb.

Knowing that you were investigating the discs, they are asking for your help to conduct an unbiased test of their key. You are to test the key by determining if, given the order of the discs, a message is revealed.

Remember, models may change over time. If you change yours, make sure to record the change and the rationale behind the change in your science notebook. Good luck!

Have the students complete the heading for the 4th column of their data tables, “Possible Letter”.

Often the key choices for a specific disc do not resemble the student’s hypothesis. The model, when extended, has broken down! Does this ever happen to scientists? What do they do when this happens? This requires testing and retesting of the model. Once realized, this is an excellent time to</td>
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casually remind students how a scientific method actually works – it isn't a plug and chug equation where a conclusion pops out at the end. Depending on the intended research, a scientist is just as likely to start by analyzing data and the resulting conclusion as they are starting with a question. Ask students, "How does scientific methodology support the use of models?" (It requires the researcher to constantly revisit their hypothesis and tweak the models to get the best representation of the concept possible.) Phrase reads: May the fleas of a thousand camels infest your armpits. Students should work the puzzle from all aspects – from clues with the blacks discs and as a word puzzle. (Hint: there is a one-letter word in the puzzle – what are the possible words in English could this be? A or I)		
Assessment: After solving the phrase, students write a summary of the task. A complete summary will include: 1. How they followed a scientific method in order to solve the mystery of the hidden tomb. 2. A discussion of the various strategies they used to solve the final puzzle (Testing the Key). 3. A discussion concerning the advantages and disadvantages of using scientific models. Science Notebooks are turned in: basic organization and analysis of data collection is the assessment focus. Participation is assessed as the lab is in progress.	See Attached	
Extensions: Design a 3-D (mobile-like) Bohr Model of an element. Each model will be labeled with a 3x5 card. One side of the card will detail general information about the element, common compounds and isotopes of the element including historical and commercial significance. The other side of the card will evaluate the model for accuracy; noting the limitations and accuracy of the model presented (e.g.: Electrons do not orbit the nucleus like planets orbit a sun).		

Curse of the Hidden Tomb Rubric

CATEGORY	**1**	**2**	**3**	**4**
Scientific Concepts	Summary illustrates inaccurate understanding of scientific concepts underlying the lab.	Summary illustrates a limited understanding of scientific concepts underlying the lab.	Summary illustrates an accurate understanding of most scientific concepts underlying the lab.	Summary illustrates an accurate and through understanding of scientific concepts underlying the lab.
Science Notebook	Notes are rarely taken or of little use.	Dated, notes are taken occasionally, but accuracy of notes might be questionable.	Dated, clear, accurate notes are taken occasionally during lab.	Clear, accurate, dated notes are taken regularly during lab.
Summary	Summary describes the information learned OR the methodology used.	Summary describes the information learned AND the methodology used.	Summary describes the information learned, methodology used, and a possible advantage OR disadvantage of the model.	Summary describes the information learned, methodology used, and a possible advantage AND disadvantage of the model.
Participation	Participation was minimal OR student was hostile about participating.	Completed the task but did not appear very interested. Focus was lost on several occasions.	Used time well. Stayed focused attention on the task most of the time.	Used time well in lab and focused attention on the task.

Resource:
Scientific Models
General Information

Source:
Developing Models – Teacher Background Information
CSI: Climate Status Investigations
The Keystone Center, Keystone, Colorado
Written in January 2000 and edited 2006 by Dr. Donald E. Simanek

Students may ask:

What is a model?

Scientists have many definitions on what a scientific models is and what it represents. Simply, a scientific model is defined as a mental or physical depiction of a process or a structure. Models rely on both direct and indirect evidence gathered through experimentation. Typically the goal of a model is not to show that a phenomenon exists, but to serve as an aid in thinking about how the phenomenon might come about or why it is the way it is. Another way to put this is that a model helps the learner understand an explanatory structure, a story about the way things are related and the causes for the behavior we observe. Casual observation shows us that nature has reliable regularities and patterns of behavior. Measurement and use of scientific apparatus confirms this and reveals even more detailed patterns in nature. Through systematic and careful study scientists have found that these regularities can be modeled, often with very precise mathematical models.

Can models break down?

Sometimes models breakdown when extended. (A weather forecast is less precise the longer it's projected, meaning tonight's forecast for tomorrow will be more precise than the forecast for next week.) Extending the model involves the process of extending (extrapolating) a model or a low beyond its known range of applicability. Sometimes extrapolation of a low or model to a new situation actually works, and sometimes it fails terribly. This tells us that we need to rigorously test each model for validity, in all possible situations, and these tests should be capable of exposing the models flaws – or showing us what isn't completely true with the model.

Even when a model survives such testing, we should only grant it "provisional" acceptance. In the future, cleverer people with more sophisticated measuring techniques and more advanced scientific technology and understandings may expose flaws in our models that went unnoticed.

What do we do with a model once it's shown to be flawed?

When models are discovered to be incomplete, we often fix them by tweaking the model's details until it works. However, when rapid advances in experimental observation occurs, a model may be fond so seriously inadequate to accommodate the new data, that we may scrap a large part of it and start over with a new model. (Relativity and Quantum Mechanics are examples.)

So, those old models are wrong?

When such upheavals occur, and old models are replaced with new ones, that doesn't mean the old ones were "wrong". They still work within the original scope of applicability. Newton's physics wasn't suddenly wrong, nor were its predictions found unreliable or incorrect when we adopted Einstein's relativity. Relativity had greater scope of applicability than Newtonian physics. But it also relied on different concepts.

Can we ever find the absolute answer with models?

The history of science has been a process of finding successful descriptive models of nature. First, we found the easy ones. As science progressed, scientists were forced to tackle the more subtle and difficult problems. So powerful are our models by now that we often fool ourselves into thinking that we are very clever to have been able to figure out how nature "really" works. But on sober reflection, we realize that we have simply devised a more sophisticated and detailed description.

The idea that we can find absolute and final truths is oversimplified. If there are any underlying "truths" of nature, our models are just close approximations to them – useful descriptions that "work" by correctly predicting natures' behavior. We are not in a position to answer the philosophical question "Are there any absolute truths?" Though our laws and models (theories) become better and better, we have no reason to expect they will ever be perfected. So we have no justification for absolute faith or belief in them. They may be replaced someday by something quite different in appearance and with different underlying concepts. At least they will be modified. But that won't make the old models "untrue". The old models will work as well as they always did. And we can do science quiet well without answering all these questions – questions that many not even have answers. Science limits itself to more finite questions for which we can arrive at practical answers.

THE CURSE OF THE HIDDEN TOMB

1	2	3	4	5	6
A OR H	T	M OR D	Y	R	U
7	**8**	**9**	**10**	**11**	**12**
O OR P	I	C	S OR L	F	E OR N