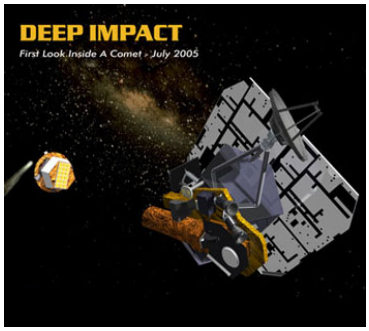

Exploring Comets and Modeling for Mission Success

National Science Education Standards Alignment

Created for Deep Impact, A NASA Discovery mission
Maura Rountree-Brown and Art Hammon
Educator-Enrichment

Grades 5 – 8

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions that can be answered through scientific investigations.
  - *Exploring Comets: Reflections on comets, missions and modeling*
- Develop descriptions, explanations, predictions, and models using evidence.
  - *Make a Comet and Eat It!, Chemistry and Thermodynamics of Ice Cream, Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*
- Think critically and logically to make the relationships between evidence and explanations.
  - *Make a Comet and Eat It!, Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*
- Communicate scientific procedures and explanations.
  - *Make a Comet and Eat It!*

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, or events; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
  - *Make a Comet and Eat It!, Chemistry and Thermodynamics of Ice Cream, Comet on a Stick, Paper Comet with a Deep Impact, Comet Models Based on the Deep Impact Mission, and Deep Impact Comet Modeling*
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
  - *A Comet's Place in the Solar System, Exploring Comets: Reflections on comets, missions and modeling, Deep Impact Comet Modeling, Deep Impact: Interesting Comet Facts, and Small Bodies Missions*

- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
  - *Consider This!, A Comet's Place in the Solar System, Deep Impact Comet Modeling*
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.
  - *Exploring Comets: Reflections on comets, missions and modeling, A Comet's Place in the Solar System*

Physical Science

Properties and changes of properties in matter

- A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.
  - *Make a Comet and Eat It!, Chemistry and Thermodynamics of Ice Cream*
- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved.
  - *Chemistry and Thermodynamics of Ice Cream*

Motions and forces

- The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.
  - *Comet on a Stick, Paper Comet with a Deep Impact*
- Unbalanced forces will cause changes in the speed or direction of an object's motion.
  - *Comet on a Stick, Paper Comet with a Deep Impact*

Transfer of energy

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
  - *Chemistry and Thermodynamics of Ice Cream*
- Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.
  - *Chemistry and Thermodynamics of Ice Cream*
- In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.
  - *Chemistry and Thermodynamics of Ice Cream*

Earth and Space Science

Earth in the solar system

- The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system.
  - *Small Bodies Missions, A Comet's Place in the Solar System, Ten Important Comet Facts, The Deep Impact Comet Acrostic, Comet on a Stick, Paper Comet with a Deep Impact*
- Most objects in the solar system are in regular and predictable motion.
  - *A Comet's Place in the Solar System, Ten Important Comet Facts, The Deep Impact Comet Acrostic, Comet on a Stick, Paper Comet with a Deep Impact*
- Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system.
  - *A Comet's Place in the Solar System*

Science and Technology

Abilities of technological design

- Design a solution or product.
  - *Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*
- Implement a proposed design.
  - *Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*
- Evaluate completed technological designs or products.
  - *Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*

Understandings about science and technology

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations.
  - *Consider This!, A Comet's Place in the Solar System*
- Many different people in different cultures have made and continue to make contributions to science and technology.
  - *Consider This!, Small Bodies Missions*
- Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.

- *A Comet's Place in the Solar System, Small Bodies Missions*

– Perfectly designed solutions do not exist.
  - *Comet on a Stick, Paper Comet with a Deep Impact*

Science in Personal and Social Perspectives

Personal health

– Natural hazards include possible impacts of asteroids.
  - *Briefly addressed in Consider This! And Ten Important Comet Facts*

Science and technology in society

– Science and technology have advanced through contributions of many different people, in different cultures, at different times in history.
  - *Consider This!, A Comet's Place in the Solar System*

History and Nature of Science

Nature of science

– Scientists formulate and test their explanations of nature using observation.
  - *A Comet's Place in the Solar System, Deep Impact Comet Modeling*

Unifying Concepts and Processes (K-12)

Evidence, models, and explanation

- *Make a Comet and Eat It!, Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*

Grades K-4

Science as Inquiry

Abilities necessary to do scientific inquiry

– Plan and conduct a simple investigation.
  - *Make a Comet and Eat It!, Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*

– Use data to construct a reasonable explanation.
  - *Make a Comet and Eat It!, Comet on a Stick, Paper Comet with a Deep Impact, and Comet Models Based on the Deep Impact Mission*

– Communicate investigations and explanations.
  - *Make a Comet and Eat It!*

Understandings about scientific inquiry

– Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
  - *Make a Comet and Eat It!, Comet on a Stick, Paper Comet with a Deep Impact, Comet Models Based on the Deep Impact Mission, and Deep Impact Comet Modeling*

- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
  - *Make a Comet and Eat It!, Comet on a Stick, Paper Comet with a Deep Impact, Comet Models Based on the Deep Impact Mission, and Deep Impact Comet Modeling*
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
  - *Consider This!, A Comet's Place in the Solar System, Deep Impact Comet Modeling*

Physical Science

Properties of objects and materials

- Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances.
  - *Make a Comet and Eat It!*
- Materials can exist in different states--solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.
  - *Make a Comet and Eat It!*

Position and motion of objects

- The position of an object can be described by locating it relative to another object or the background.
  - *Comet on a Stick, Paper Comet with a Deep Impact*
- An object's motion can be described by tracing and measuring its position over time.
  - *Comet on a Stick, Paper Comet with a Deep Impact*

Earth and Space Science

Changes in the earth and sky

- Objects in the sky have patterns of movement.
  - *A Comet's Place in the Solar System, Ten Important Comet Facts, The Deep Impact Comet Acrostic, Comet on a Stick, Paper Comet with a Deep Impact*

Science and Technology

Understanding about science and technology

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
  - *Consider This!, Small Bodies Missions*
- People have always had problems and invented tools and techniques (ways of doing something) to solve problems.
  - *Small Bodies Missions*
- Tools help scientists see, measure, and do things that they could not otherwise see, measure, and do.
  - *A Comet's Place in the Solar System, Small Bodies Missions*

Grades 9-12

Science as Inquiry

Understandings about scientific inquiry

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
  - *Make a Comet and Eat It!, Chemistry and Thermodynamics of Ice Cream, Comet on a Stick, Paper Comet with a Deep Impact, Comet Models Based on the Deep Impact Mission, Deep Impact Comet Modeling, Small Bodies Missions*
- Scientists conduct investigations for a wide variety of reasons.
  - *Exploring Comets: Reflections on comets, missions and modeling, Small Bodies Missions*
- Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.
  - *Small Bodies Missions*

Physical Science

Structure and properties of matter

- Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus.
  - *Chemistry and Thermodynamics of Ice Cream*
- An element is composed of a single type of atom.
  - *Chemistry and Thermodynamics of Ice Cream*
- Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.
  - *Chemistry and Thermodynamics of Ice Cream*
- The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.
  - *Chemistry and Thermodynamics of Ice Cream*

- Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.
  - *Chemistry and Thermodynamics of Ice Cream*

Motions and forces

- Gravitation is a universal force that each mass exerts on any other mass.
  - *A Comet's Place in the Solar System*

Conservation of energy and the increase in disorder

- In all energy transfers, the overall effect is that the energy is spread out uniformly.
  - *Make a Comet and Eat It!, Chemistry and Thermodynamics of Ice Cream*

Earth and Space Science

The origin and evolution of the earth system

- The sun, the earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago.
  - *Consider This! Ten Important Comet Facts*

Science and Technology

Understandings about science and technology

- Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
  - *A Comet's Place in the Solar System, Small Bodies Missions*

History and Nature of Science

Science as a human endeavor

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise.
  - *Small Bodies Missions*