National Aeronautics and
Space Administration

Educational Product	
Educators	Grades 5–8

STARDUST

ACTIVITY GUIDE

Think SMALL in a BIG way

A DISCOVERY MISSION

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL 400-855 8/99
EG-1999-08-010-JPL

Think SMALL in a BIG Way

An Educator's Activity Guide for the STARDUST Mission for Grades 5-8

Brought to you by

National Aeronautics and Space Administration

Jet Propulsion Laboratory, California Institute of Technology

and

The STARDUST Opportunity and Outreach Team:

Challenger Center for Space Science Education

The JASON Foundation for Education

Omniplex at Kirkpatrick Science and Air Space Museum

Acknowledgments

This activity guide has been developed by the STARDUST Opportunity and Outreach Team as part of the Jet Propulsion Laboratory's STARDUST mission educational outreach program. Team members include:

Challenger Center For Space Science Education

JASON Foundation for Education

Omniplex at Kirkpatrick Science and Air Space Museum

Advisory Board Members

Donald Brownlee, Ph.D.
STARDUST Principal Investigator
University of Washington

Mary Gromko
State Science Coordinator
Colorado Department of Education

Ellen Hardwick, Ph.D.
Aerospace Education Services Program
National Aeronautics and Space Administration

Wendell Mohling, Ph.D.
Associate Executive Director of
Conventions and Professional Programs
National Science Teachers Association

A special thanks for the activities that were developed and contributed to this activity guide by the Education Outreach Team members:

"Comet Cratering"—Challenger Center for Space Science Education.

"Cookin' Up a Comet"—this activity most likely originated from Dennis Schatz at the Pacific Science Center or Lynn Bondurant at NASA Lewis Research Center. This version was compiled by Challenger Center.

"The Incredible Edible Comet"—Challenger Center developed this activity based on a recipe from Kirkpatrick Science and Air and Space Museum at Omniplex, Oklahoma City, Oklahoma.

"Famous Comets"—developed by Challenger Center

"Voyage of Discovery"—this activity is based on Challenger Center's *Voyages Across the Nation,* a partnership between Challenger Center, the Smithsonian Institution, and NASA.

"Feedback Loops"—adapted from the JASON Core Curriculum, prepared by the National Science Teacher's Association.

"Navigation Simulation"—adapted from the JASON Core Curriculum.

"Candy Model Spacecraft"—developed by Challenger Center.

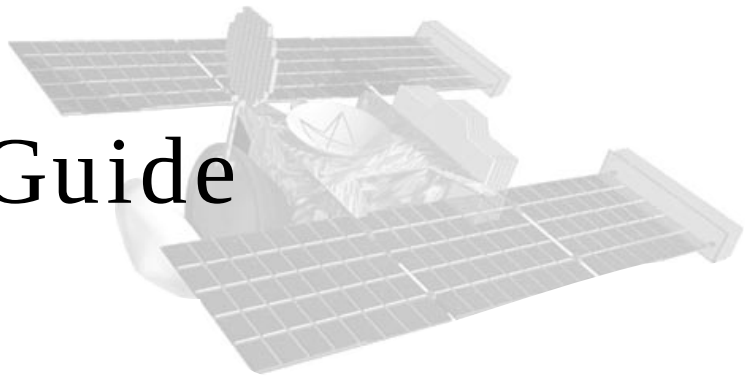
"Egg Drop Sample Return Capsule"—adapted from NASA Spacelink.

"Aerogel Clay Collector Activity Overview"—developed by Challenger Center based on the aerogel-lo activity from Kirkpatrick Science and Air and Space Museum at Omniplex.

"Paint by the Numbers"—from the NASA publication *Space Based Astronomy Teacher's Guide.*

Table of Contents

About This Guide



This guide focuses on parts of the Solar System that do not get much attention: the small bodies of the Solar System, namely asteroids, meteoroids, and comets. These small bodies play a significant role in the formation of the Solar System, and they can leave a lasting impact in their own right. For more information about the basics of asteroids, meteoroids, and comets and their significance, see the section Think SMALL in a Big Way on page 1.

Small bodies tie into the *National Science Education Standards* by the National Research Council and *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics. To see how the activities have been correlated to the national standards, consult the Activity Matrix on page ix.

Each section contains background information and activities that support the section topic. The guide is broken into sections that touches upon various facets of a mission to explore Comet Wild 2 (pronounced "Vilt," after its discoverer). The first dedicated U.S. mission to a comet is the STARDUST mission, launched February 7, 1999. For more information about STARDUST, see page 5. Teachers can use this guide with great flexibility, focusing on any aspect of a mission that most suits his or her curriculum, current events, etc. By picking at least one activity from each section, students gain a breadth of understanding about mission planning and execution couched in a real-world context of an actual mission, STARDUST.

The first section starts by exploring the current thinking about comet anatomy and structure. The second section part looks at where comets reside in the Solar System and their orbits. The third section examines some of the intricacies of navigating a spacecraft to a comet, followed by the fourth section that deals with spacecraft design and testing. Finally, students investigate aspects of spacecraft technology for studying Comet Wild 2. This includes transmitting data and designing a device to capture particles to bring back for Earth studies.

Fact Sheets are located at the end of the guide since several activities make use of the same ones. For the teacher selecting just one or two activities to do in class, these Fact Sheets can be used with any activity to overview basic concepts. The vocabulary at the back of the guide is another such handy reference. It contains concise definitions of key vocabulary for small bodies. As missions progress, updates occur continuously on the Internet. The latest information can be found on the NASA mission homepages listed in the Resources section at the end of the activity guide.

While teachers are welcome to pick and choose among the activities, we have structured the guide so that those teachers, who are so inclined, can simulate the STARDUST mission. We suggest kicking off a STARDUST unit with the teacher demonstration Cookin' Up a Comet and other activities from Comet Basics. Hold a "mission briefing" tasking students to work in teams to design and implement the STARDUST mission. Use activities from each unit to address different aspects of the mission. The following is a logical sequence of mission events and corresponding activitities.

MISSION EVENT	ACTIVITY
Mission briefing	STARDUST Fact Sheet
Spacecraft design	Candy Model Spacecraft
Comet orbit	Elliptical Orbits
Spacecraft navigation	Navigation Simulation
Comet rendezvous	Cookin' Up a Comet
Data transmission	Paint by the Numbers
Particle capture	Aerogel Clay Collector
Sample return	Egg Drop Sample Return Capsule

Activity Matrix
for National Science Education Standards
and Curriculum and Evaluation Standards for School Mathematics
Grades 5-8

	Think SMALL in a Big Way		Comet Basics			Comet Origins and Travels		Rendezvous with Wild 2 Comet		Spacecraft Design & Testing		Technology for Studying Comets	
	Comet Cratering	Mysterious Seas and Skies	Cookin' Up a Comet	Incredibe Edible Comet	Famous Comets	Voyage of Discovery	Elliptical Orbits	Feedback Loop	Navigation Simulation	Candy Model Spacecraft	Egg Drop Sample Return	Aerogel Clay Collector	Paint by the Numbers
NATIONAL SCIENCE STANDARDS													
Unifying Concepts and Processes													
Systems, order, and organization			•	•	•	•	•	•	•	•	•	•	•
Evidence, models, and explanation	•		•	•	•	•	•			•	•	•	•
Change, constancy, and measurement	•					•	•	•	•		•	•	
Evolution and equilibrium											•	•	
Form and function				•	•	•	•	•	•	•	•	•	
Science as Inquiry													
Abilities necessary to do scientific inquiry	•		•					•	•	•	•	•	•
Understanding about scientific inquiry	•		•					•	•	•	•	•	
Physical Science													
Properties and changes of properties in matter	•		•	•							•	•	
Motions and forces	•		•	•			•	•	•		•	•	
Transfer of energy	•		•	•							•	•	
Earth and Space Science													
Structure of the Earth system	•	•											
Earth's history	•	•			•								
Earth in the Solar System	•	•				•						•	
Science and Technology													
Abilities of technological design					•			•	•	•	•	•	•
Understanding about science and technology					•			•	•	•	•	•	•
Science in Personal and Social Perspectives													
Science and technology in society					•			•	•	•	•	•	
History and Nature of Science													
Science as human endeavor				•	•			•	•	•	•	•	•
Nature of science		•						•	•	•	•	•	•
History of science					•					•	•	•	•
National Mathematics Standards													
Mathematics as Problem Solving											•		
Mathematics as Communication		•				•		•	•		•	•	•
Mathematics as Reasoning	•							•	•		•		
Mathematical Connnections						•		•	•		•		•
Number and Number Relationships								•	•				
Computation and Estimation	•	•				•		•	•		•		
Patterns and Functions							•		•				•
Algebra		•									•		
Geometry													•
Measurement	•		•			•		•	•		•	•	