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SCIENCE

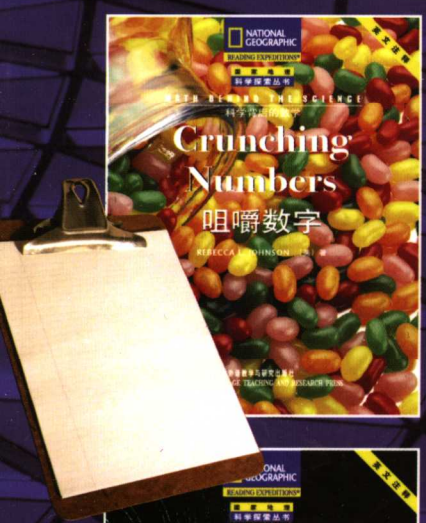
自然科学

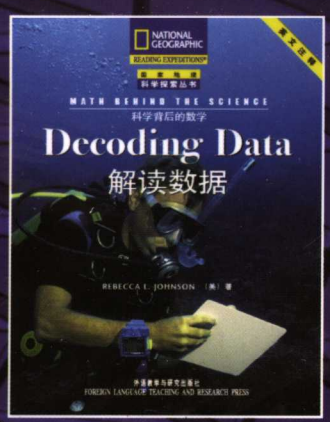
Math Behind the Science

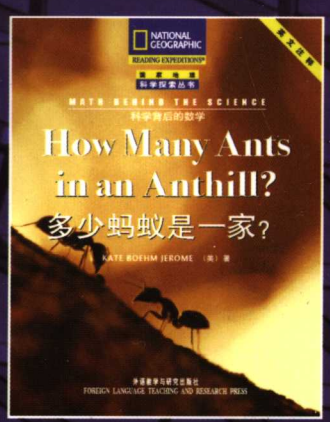
科学背后的数学

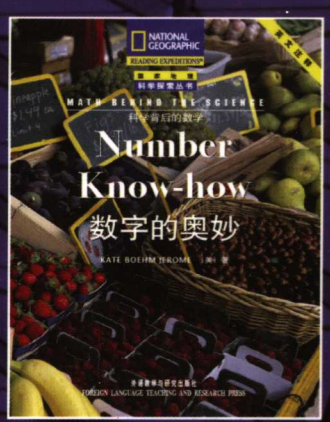
TEACHER'S GUIDE & ASSESSMENTS

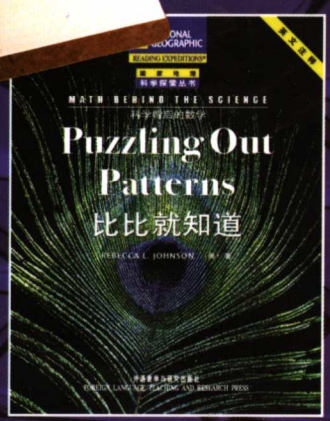
教师指导与评估手册

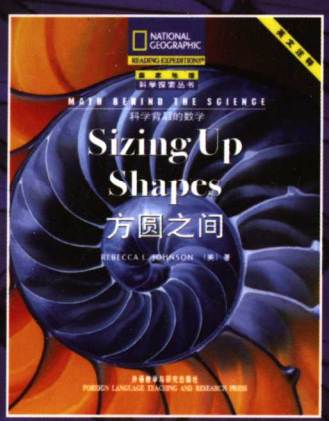


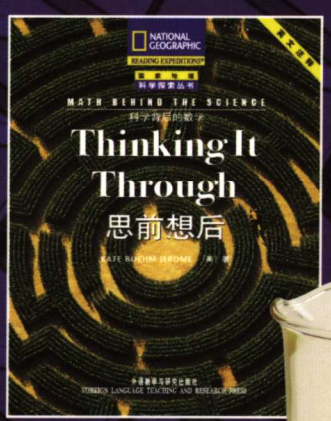


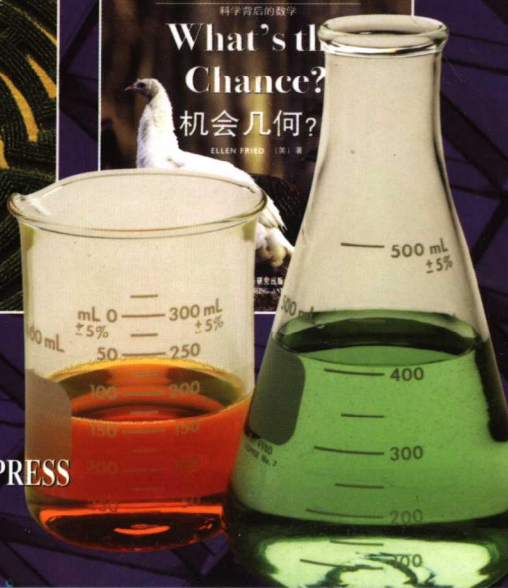












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美国国家地理学会　编著

Lesson Notes

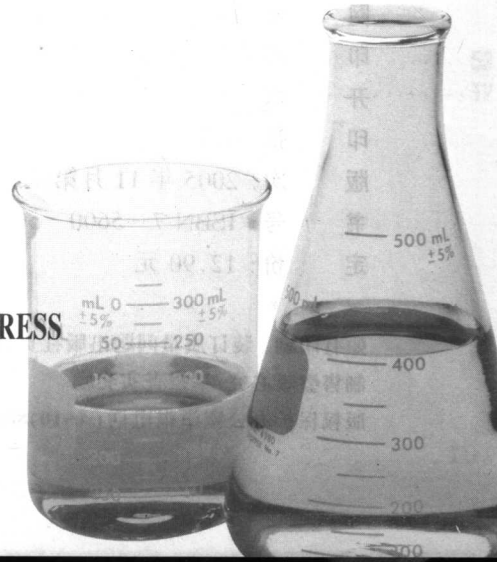
课程教案

Activity Masters

课堂活动

Teacher Resources

教学资源



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Series Overview
系列概述

简介（Introduction）

“科学背后的数学”系列讨论了数学方法与科学研究方法之间的关系。系列中的每册书以培养学生对非小说类作品的阅读技巧为目的，通过严谨的叙述，在介绍核心科学概念的同时，帮助读者培养数学技巧。

本系列运用不同的体裁、组织形式以及风格各异的行文和图表，帮助学生掌握非小说类作品的格式。同时，本系列还使用了大量能够激发学生兴趣的形式来表现科学内容。

本系列中每一本书的结构都力图帮助学生建立一个知识框架或加深他们对某个领域的理解：

引言（Introduction）通过数学方法在实际科学研究中的应用来吸引学生的注意力。

接下来的每个章节分别在实际科学研究中具体介绍不同的数学概念或方法，让学生在了解数学技巧的同时涉猎各类科学课题。

“科学背后的数学”系列还有一些特色项目可以激发学生的学习兴趣：

“来自科研现场的邮件”（E-mail from the Field）在每章开头用通俗易懂的电子邮件为本章将介绍的数学概念设定具体的科学研究背景。

“算一算！”（Figuring It Out!）引导学生逐步练习运用本章介绍的数学方法。

“数学顾问”（Math Mentor）为学生提供应用书中介绍的数学及科学知识的练习。

“数学备忘录”（Math Notebook）用有趣的信息和更多可供探索的资源来鼓励学生在课下进一步自学。

注重读写能力（Focus on Literacy）

培养阅读理解技巧

每本书都为学生提供了培养、练习和扩展阅读技巧的机会，让他们把自己的阅读技巧应用到具有不同结构、格式和图表元素的非小说类作品中去。

本系列介绍了以下阅读技巧：

识别主题和细节（Identify main ideas and details）
归纳一般规律（Make generalizations）
识别因果关系（Identify cause-and-effect relationships）
运用专业词汇（Use specialized words）
得出结论（Draw conclusions）
作出判断（Make judgments）
运用上下文线索（Use context clues）
确定事件的顺序（Identify the sequence of events）
概括总结（Summarize）
比较和对比（Compare and contrast）
用自己的话解释（Paraphrase）

理解非小说类作品的体裁、文本特征和图表

善于从非小说类作品中获得信息的读者对这类作品的各种体裁和格式都很熟悉。要有效地利用非小说类作品的各种特点，就要首先了解这类作品提供信息的材料。“科学背后的数学”系列中涉及到许多非小说类作品的特征：

体裁（Genres）

说明文（Expository）

文本特征（Text Features）

标题（Headings）
插图说明和标签（Captions and labels）

书的组成部分（Parts of a Book）

目录（Contents）　　索引（Index）

图表信息（Graphic Information）

照片（Photographs）　　插图（Illustrations）

此为试读，需要完整PDF请访问：www.ertongbook.com

文章对比阅读

最近关于学生阅读行为和水平的调查结果显示，让学生有机会阅读和对比多篇文章有助于提高他们的阅读技巧。本系列围绕同一个主题——科学背后的数学——组织了不同的文章，为学生提供对比阅读的绝好机会。学生可以就下列问题展开讨论。

对比（Compare）——这几本书各自的结构是怎样的？它们之间有哪些相同点和不同点？

评价（Evaluate）——这些信息表述得是否清楚？哪些辅助手段有助于学生对主题的理解？

总结（Generalize）——这个系列中每本书的主题有哪些相同点和不同点？这些主题对理解数学和科学概念有什么帮助？

注重数学和科学知识（Focus on Math and Science）

培养数学和科学研究技能

“科学背后的数学”系列的每一本书都为学生培养和应用基本的数学和科学研究技能提供了机会。本书中的课程教案也帮助教师创造机会，让学生在培养科学研究思路和技能的同时学习各种数学和科学概念、技巧及方法。“科学背后的数学”系列主要介绍了下列概念、方法和技巧：

- 《咀嚼数字》——估算、数据分析、空白表格程序以及计算机
- 《解读数据》——收集数据并用线图、条形图和圆形图展示数据
- 《多少蚂蚁是一家？》——标度和测量、运用公制、估算
- 《数字的奥妙》——位值和基准、心算、估算并确定合理的结果
- 《比比就知道》——比例、制作成比例模型、绘制比例
- 《方圆之间》——多边形、六边形、球形
- 《思前想后》——维恩图、得出结论、关系和模式
- 《机会几何？》——概率和统计学

Lesson Overview
课程概述

课程概述（Overview）——帮助教师快速选书备课

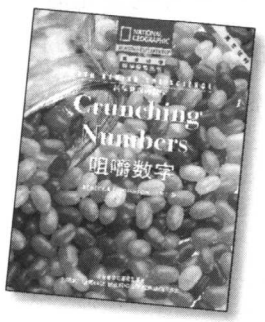
概要（Summary）
此处简要说明书中的主要观点和重要细节。

科学背景（Science Background）
此处就书中涉及的地点、人物和科学主题提供补充信息，为该书提供背景知识。

学习目标（Learning Objectives）
此处列出了在非小说类作品的特点、体裁，以及阅读、写作和科学研究技能等方面的学习目标，方便教师备课。

Overview

Crunching Numbers
咀嚼数字



By Rebecca L. Johnson

Summary

Three important mathematical tools that scientists use to work with large numbers are a calculator, a computer spreadsheet, and a supercomputer. Scientists in different parts of the world depend on these technological inventions, as well as the strategies of estimating and rounding, to make working with numbers easier. These tools and strategies are used for research, such as tracking migration routes, studying the life cycles of bacteria, or creating weather forecasts. In each scientific field, mathematical tools and strategies are important to the study of science.

Science Background

When working with large, almost incomprehensible numbers, scientists have many useful tools and strategies at their disposal. Estimation is one of the most important strategies for quickly making sense of large numbers. To process large amounts of data, a computer is essential. The first "computers" were ancient calculating machines such as the abacus—a series of beads that were moved by hand along rods. In the mid-1900s the first electronic computers were invented. Since then, electronic computers have gotten smaller, faster, and more powerful with every advance in computer technology.

Learning Objectives

Science

- Understand that scientists use tools and math strategies to work with large numbers
- Explore how the strategies of estimating and rounding make large numbers easier to work with
- List several tools that help people make sense of large numbers
- Compare a computer spreadsheet with an ordinary table
- Identify some of the uses of supercomputers

Process Skills

Skill Focus
- Estimating

Supporting Skills
- Interpreting data
- Observing
- Communicating

Reading Skills

Genre: Expository

Skill Focus
- Identify cause-and-effect relationships
- Use specialized words

Supporting Skills
- Summarize
- Make generalizations
- Compare and contrast
- Make judgments

10

注重阅读（Focus on Reading）——关于帮助学生在阅读前后及阅读过程中培养技巧的建议

Focus on Reading

Before Reading

Activate Prior Knowledge
Have students brainstorm ways they use mathematical tools, such as calculators. Ask:

How does the tool help you in school?

How does the tool help you at home, besides for homework?

Have students make a table that lists the tools and describes how each one helps solve a problem or answer a question. Explain that the book they are about to read tells about some of the mathematical tools scientists use and that some of these tools are the same ones students use. Encourage them to return to the table after reading to add any new information from the book.

Tool	How It Helps

Preview
Give students time to flip through the book, paying attention to chapter titles, photos, captions, tables, and special features. Ask:

What information do the captions provide?

What do the chapter titles tell you about how this book is organized?

What do you think the Figuring It Out! features tell you?

Before reading, explain that the scientists' e-mail addresses and names are fictitious. The research situations presented, however, reflect typical science projects and data. Point out that real-life scientists use math in ways that are similar to those presented here.

Set Purpose
Ask students whether this book reminds them of other books they have read. Help them set a purpose for reading. Ask:

What do you want to find out by reading this book?

Encourage students to give reasons for their answers.

Vocabulary Strategy: Use Specialized Words
Activity Master, Page 14

Explain to students that many of the words in this book relate to calculating numbers in some way. Have students use *Crunching Numbers* and the dictionary to find the meaning of each word. On the Activity Master on page 14, students write a sentence telling how each word relates to calculating numbers. Students will be using these words:

calculator
cell
estimate
rounding
spreadsheet
supercomputer

My Notes

Writing Skills

Writing Focus
- Write a newspaper ad (persuasive)

Supporting Skills
- Use the writing process
- Conduct research
- Write for a specific purpose

Speaking/Listening
- Give an oral presentation

知识热身（Activate Prior Knowledge）
这些用来热身的知识常常可以用图表进行组织。

预习（Preview）
预习非小说类作品可以帮助学生理解作品的结构，预测作品将提供哪类信息。

词汇（Vocabulary Strategy）
学生在阅读前可以使用“课堂活动”（Activity Master）学习课文中的关键词汇。

注重阅读 (Focus on Reading) ——关于帮助学生在阅读前后及阅读过程中培养技巧的建议

阅读技巧 (Read Strategically)
每一种重要的阅读理解技巧都配有相应的“课堂活动”(Activity Master)。“技巧点拨”(Strategy Tip)提供具体的建议，帮助学生检测自己的阅读效果。

课堂互动 (Responding)
此处的讨论问题可以帮助学生考查书中的主要观点。

写作和研究 (Writing and Research)
学生可以就书中的主题进行调查研究，然后用各种体裁和形式进行写作。

课堂交流 (Communicating)
课堂活动可以帮助学生培养听、说等交流技巧和观察能力。

Focus on Reading (continued)

During Reading

Read Strategically: Identify Cause-and-effect Relationships
Activity Master, Page 15

Assign each chapter of the book as independent reading. Have students use the Activity Master on page 15 to help them recognize the effect of each cause listed. Discuss how cause-and-effect relationships are important in science.

Strategy Tip: Paraphrase
If students have difficulty understanding a portion of the text, suggest that they retell it in their own words, or paraphrase. Explain that paraphrasing helps identify the parts of the text they do not understand. If they are still having difficulty restating a passage, students can ask for clarification during the follow-up class discussion.

After Reading

Responding
Initiate a class discussion to assess reading comprehension. Ask:

How do scientists use math to investigate scientific questions? (See pages 9, 14-15, and 18 in the student book.) **(summarize)**

Explain how you can use a sample of a population to estimate the size of the entire population. (See page 8.) **(make generalizations)**

How does using a calculator compare with using a supercomputer? (See pages 9 and 18-19.) **(compare and contrast)**

Why is it important to learn math even if we have calculators and computers to do calculations? (See pages 9 and 15.) **(make generalizations)**

How is a data table that you make in a notebook similar to a computer spreadsheet? How is it different? (See page 15.) **(compare and contrast)**

Why are supercomputers needed to help weather forecasters make the most accurate forecasts? (See pages 17-18.) **(summarize)**

Which scientist in the book do you think has the most interesting job? Why? **(make judgments)**

Writing and Research: Write a Newspaper Ad
Activity Master, Page 16

Tell students that they will be creating a full-page newspaper ad for one of the tools discussed in *Crunching Numbers* (calculator, spreadsheet, or supercomputer). Students should explain the benefit of the tool and describe how the tool works. Have them include the history of the tool to add interest and background. The ads should convince people to use this tool because it is the best choice for the needs described in the ad. The ad should include illustrations. Students can use the Activity Master on page 16 to guide them in organizing their ideas.

Communicating: Speaking/Listening
Give an oral presentation
Students can present their ads and a sample or photo of their tool to convince the class that this tool is the best choice for crunching numbers.

Students reading aloud should

- ✓ speak clearly
- ✓ make eye contact with listeners
- ✓ use emphasis as appropriate

Listeners should

- ✓ listen politely
- ✓ identify the main points of the presentation
- ✓ ask questions to clarify

12

拓展和测试（Extend and Assess）——科学活动、测试和拓展活动为教学提供了丰富的内容

Extend and Assess

Focus on Math

Figuring It Out!

Process Skill: Estimating

Extending page 11: Have students apply the steps for rounding numbers to the nearest hundred and to the nearest ten. Use Jake's estimate of 3,892 butterflies.

Answer: 3,900; 3,890

Discuss how rounding to the lowest place value (tens) gives the most accurate estimate of butterflies per square kilometer when Jake multiplies by 50. But rounding to the highest place value (thousands) gives a figure that Jake can quickly multiply by 50 in his head. That answer may be close enough for his purposes.

Extending page 18: Ask students how many calculations the ES can perform per second.

Answer: 41 trillion

Math Mentor

Tips Invite students to form new words by combining the word parts *mega-*, *giga-*, and *tera-* with existing words. Students should explain the meaning of each new word. They do not have to use the meaning of the word part as it applies to computer language.

Answers to Try Another One!
A megaflop is a million flops. A gigaflop is a billion flops. A teraflop is a trillion flops.

Math/Science Strategies: Words Count!

Activity Master, Page 17

Students can use the Activity Master on page 17 to identify words that begin with other math-related word parts. They can then use a dictionary to find the meaning of each word part and of each word.

Assessment Options

Use the following assessment options to assess students' understanding of *Crunching Numbers*.

Questions

Use the following questions during individual conferences or ask students to write the answers in their notebooks:

1. What is one example of how scientists use math in their work?
2. What three math strategies might you use to figure out about how many blades of grass are in a lawn?
3. What makes a spreadsheet helpful for answering "What if" questions?
4. Describe what a supercomputer is and what it can do.
5. Identify two scientists from the book and tell about their work.

Assessment Activity

Students can create a poster describing a calculator, a spreadsheet, and a supercomputer. In addition to a visual of each tool, the posters should give the importance of each tool, when or why each tool would be used, and how each tool crunches numbers.

Posters should

- ✓ be carefully prepared
- ✓ include a title
- ✓ accurately describe each tool
- ✓ include a visual of each tool
- ✓ use correct grammar and mechanics

Multiple-choice Test

Use the multiple-choice test on page 82.

Cross-curricular Connection

Social Studies

Students can conduct research to learn about the origins of calculating machines. They can create a time line showing the development of calculating machines. Some machines students could list are the abacus, Napier's bones, slide rule, Pascaline, adding machine, handheld calculator, computer, and supercomputer.

Home-school Connection

Students can explain to family members the tools described in *Crunching Numbers*. Then they can discuss different uses for tools. For example, a supercomputer might have been used to develop medicines. A calculator might have been used to figure out the number of tiles for the kitchen floor.

13

注重科学知识（Focus on Science）
通过与科学概念和研究技能相关的实践活动来帮助学生用新的方法理解书的内容。这部分也配有相关的"课堂活动"（Activity Master）。

测试（Assessment Options）
用讨论问题、评估活动或多项选择题对学生进行评估，考查他们对书中重要概念的理解。

跨学科链接（Cross-curricular Connection）
此处提供一些活动建议，帮助学生将科学知识与数学、社会研究、音乐、艺术和文学联系起来。

家庭—学校链接（Home-school Connection）
"家庭—学校链接"给学生一些建议，让他们与家人一起讨论学到的内容。

Overview

Crunching Numbers

咀嚼数字

By Rebecca L. Johnson

Summary

Three important mathematical tools that scientists use to work with large numbers are a calculator, a computer spreadsheet, and a supercomputer. Scientists in different parts of the world depend on these technological inventions, as well as the strategies of estimating and rounding, to make working with numbers easier. These tools and strategies are used for research, such as tracking migration routes, studying the life cycles of bacteria, or creating weather forecasts. In each scientific field, mathematical tools and strategies are important to the study of science.

Science Background

When working with large, almost incomprehensible numbers, scientists have many useful tools and strategies at their disposal. Estimation is one of the most important strategies for quickly making sense of large numbers. To process large amounts of data, a computer is essential. The first "computers" were ancient calculating machines such as the abacus—a series of beads that were moved by hand along rods. In the mid-1900s the first electronic computers were invented. Since then, electronic computers have gotten smaller, faster, and more powerful with every advance in computer technology.

Learning Objectives

Science

- Understand that scientists use tools and math strategies to work with large numbers
- Explore how the strategies of estimating and rounding make large numbers easier to work with
- List several tools that help people make sense of large numbers
- Compare a computer spreadsheet with an ordinary table
- Identify some of the uses of supercomputers

Process Skills

Skill Focus
- Estimating

Supporting Skills
- Interpreting data
- Observing
- Communicating

Reading Skills

Genre: Expository

Skill Focus
- Identify cause-and-effect relationships
- Use specialized words

Supporting Skills
- Summarize
- Make generalizations
- Compare and contrast
- Make judgments

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Before Reading

Activate Prior Knowledge

Have students brainstorm ways they use mathematical tools, such as calculators. Ask:

How does the tool help you in school?

How does the tool help you at home, besides for homework?

Have students make a table that lists the tools and describes how each one helps solve a problem or answer a question. Explain that the book they are about to read tells about some of the mathematical tools scientists use and that some of these tools are the same ones students use. Encourage them to return to the table after reading to add any new information from the book.

Tool	How It Helps

Preview

Give students time to flip through the book, paying attention to chapter titles, photos, captions, tables, and special features. Ask:

What information do the captions provide?

What do the chapter titles tell you about how this book is organized?

What do you think the Figuring It Out! features tell you?

Before reading, explain that the scientists' e-mail addresses and names are fictitious. The research situations presented, however, reflect typical science projects and data. Point out that real-life scientists use math in ways that are similar to those presented here.

Set Purpose

Ask students whether this book reminds them of other books they have read. Help them set a purpose for reading. Ask:

What do you want to find out by reading this book?

Encourage students to give reasons for their answers.

Vocabulary Strategy: Use Specialized Words

Activity Master, Page 14

Explain to students that many of the words in this book relate to calculating numbers in some way. Have students use *Crunching Numbers* and the dictionary to find the meaning of each word. On the Activity Master on page 14, students write a sentence telling how each word relates to calculating numbers. Students will be using these words:

calculator
cell
estimate
rounding
spreadsheet
supercomputer

My Notes

Writing Skills

Writing Focus
- Write a newspaper ad (persuasive)

Supporting Skills
- Use the writing process
- Conduct research
- Write for a specific purpose

Speaking/Listening
- Give an oral presentation

During Reading

Read Strategically: Identify Cause-and-effect Relationships

Activity Master, Page 15

Assign each chapter of the book as independent reading. Have students use the Activity Master on page 15 to help them recognize the effect of each cause listed. Discuss how cause-and-effect relationships are important in science.

Strategy Tip: Paraphrase

If students have difficulty understanding a portion of the text, suggest that they retell it in their own words, or paraphrase. Explain that paraphrasing helps identify the parts of the text they do not understand. If they are still having difficulty restating a passage, students can ask for clarification during the follow-up class discussion.

After Reading

Responding

Initiate a class discussion to assess reading comprehension. Ask:

How do scientists use math to investigate scientific questions? (See pages 9, 14-15, and 18 in the student book.) **(summarize)**

Explain how you can use a sample of a population to estimate the size of the entire population. (See page 8.) **(make generalizations)**

How does using a calculator compare with using a supercomputer? (See pages 9 and 18-19.) **(compare and contrast)**

Why is it important to learn math even if we have calculators and computers to do calculations? (See pages 9 and 15.) **(make generalizations)**

How is a data table that you make in a notebook similar to a computer spreadsheet? How is it different? (See page 15.) **(compare and contrast)**

Why are supercomputers needed to help weather forecasters make the most accurate forecasts? (See pages 17-18.) **(summarize)**

Which scientist in the book do you think has the most interesting job? Why? **(make judgments)**

Writing and Research: Write a Newspaper Ad

Activity Master, Page 16

Tell students that they will be creating a full-page newspaper ad for one of the tools discussed in *Crunching Numbers* (calculator, spreadsheet, or supercomputer). Students should explain the benefit of the tool and describe how the tool works. Have them include the history of the tool to add interest and background. The ads should convince people to use this tool because it is the best choice for the needs described in the ad. The ad should include illustrations. Students can use the Activity Master on page 16 to guide them in organizing their ideas.

Communicating: Speaking/Listening

Give an oral presentation

Students can present their ads and a sample or photo of their tool to convince the class that this tool is the best choice for crunching numbers.

Students reading aloud should

- ✓ speak clearly
- ✓ make eye contact with listeners
- ✓ use emphasis as appropriate

Listeners should

- ✓ listen politely
- ✓ identify the main points of the presentation
- ✓ ask questions to clarify

Extend and Assess

Focus on Math

Figuring It Out!

Process Skill: Estimating

Extending page 11: Have students apply the steps for rounding numbers to the nearest hundred and to the nearest ten. Use Jake's estimate of 3,892 butterflies.

Answer: 3,900; 3,890

Discuss how rounding to the lowest place value (tens) gives the most accurate estimate of butterflies per square kilometer when Jake multiplies by 50. But rounding to the highest place value (thousands) gives a figure that Jake can quickly multiply by 50 in his head. That answer may be close enough for his purposes.

Extending page 18: Ask students how many calculations the ES can perform per second.

Answer: 41 trillion

Math Mentor

Tip: Invite students to form new words by combining the word parts *mega-*, *giga-*, and *tera-* with existing words. Students should explain the meaning of each new word. They do not have to use the meaning of the word part as it applies to computer language.

Answers to Try Another One!
A megaflop is a million flops. A gigaflop is a billion flops. A teraflop is a trillion flops.

Math/Science Strategies: Words Count!

Activity Master, Page 17

Students can use the Activity Master on page 17 to identify words that begin with other math-related word parts. They can then use a dictionary to find the meaning of each word part and of each word.

Assessment Options

Use the following assessment options to assess students' understanding of *Crunching Numbers*.

Questions

Use the following questions during individual conferences or ask students to write the answers in their notebooks:

1. What is one example of how scientists use math in their work?
2. What three math strategies might you use to figure out about how many blades of grass are in a lawn?
3. What makes a spreadsheet helpful for answering "What if" questions?
4. Describe what a supercomputer is and what it can do.
5. Identify two scientists from the book and tell about their work.

Assessment Activity

Students can create a poster describing a calculator, a spreadsheet, and a supercomputer. In addition to a visual of each tool, the posters should give the importance of each tool, when or why each tool would be used, and how each tool crunches numbers.

Posters should

- ✓ be carefully prepared
- ✓ include a title
- ✓ accurately describe each tool
- ✓ include a visual of each tool
- ✓ use correct grammar and mechanics

Multiple-choice Test

Use the multiple-choice test on page 82.

Cross-curricular Connection

Social Studies

Students can conduct research to learn about the origins of calculating machines. They can create a timeline showing the development of calculating machines. Some machines students could list are the abacus, Napier's bones, slide rule, Pascaline, adding machine, handheld calculator, computer, and supercomputer.

Home-school Connection

Students can explain to family members the tools described in *Crunching Numbers*. Then they can discuss different uses for tools. For example, a supercomputer might have been used to develop medicines. A calculator might have been used to figure out the number of tiles for the kitchen floor.

Vocabulary: Use Specialized Words

The words below are from *Crunching Numbers*. Each word has something to do with calculating numbers. Write the meaning of each word and use the dictionary to check your understanding. Then write a sentence for each word that shows how you think it relates to studying science.

Word	Meaning	My Sentence
calculator		
cell		
estimate		
rounding		
spreadsheet		
supercomputer		

Reading: Identify Cause-and-effect Relationships

As you read *Crunching Numbers*, think about how things change and what causes those changes. The effect is what happened and the cause is why it happened. Fill in the boxes below with the correct effects.

Why does it happen? (Cause)	What happens? (Effect)
1. Jake counts the monarch butterflies in their wintering grounds each year.	
2. Jake rounds the number of butterflies in each tree.	
3. Angela increases the temperature of the bacteria.	
4. Angela changes a number in a cell in the temperature column of her spreadsheet.	
5. Ismet feeds information about temperature, wind, humidity, and air pressure into computer models.	
6. Ismet finds that the forecast information her models generate does not match up with what she thinks it should be.	

Writing: Use the Writing Process

Write a Newspaper Ad

You are an ad writer who is trying to convince people to use a tool for crunching numbers. You will be writing a newspaper ad that tells why your tool is a good product. You can use *Crunching Numbers*, the Internet, and other resources to learn more about your tool.

1. Name of tool

_____

2. Describe when you would use this tool.

_____

3. Describe how the tool works.

_____

_____

4. Briefly give the history of this tool.

_____

_____

_____

5. List resources you will use to write your ad.

_____

_____

_____

6. List things you might include in your ad.

_____

_____

_____

7. On a separate sheet of paper, write your ad. Include a picture of your tool.

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