RARE DISEASES AND SCIENTIFIC INQUIRY

NATIONAL INSTITUTE OF HEALTH.

COPYRIGHT INFORMATION

Rare Diseases and

Scientific Inquiry

developed under a contract from the

National Institutes of Health

Office of Rare Diseases Research

5415 Mark Dabling Boulevard

Colorado Springs, Colorado 80918

BSCS Development Team

Jennifer Hackett, The Dalton School, New York, NY

Mark Bloom, Co-Principal Investigator

Donald Low, Mount Sinai Hospital, Toronto, ON

Paul Beardsley, Co-Principal Investigator

Jonathan Martin, National Marfan Foundation,

Brooke Bourdélat-Parks, Curriculum Developer

Port Washington, NY

Anne Westbrook, Curriculum Developer

Rebecca Kruse, Evaluator

Field-Test Teachers

Molly Stuhlsatz, Evaluator

Jean Caccioppoli, Elias Bernstein IS 7, Aberdeen, NJ

Jon Adams, Project Assistant

Nathaniel Franck, Our Lady of Guadalupe,

Annette Plemmons, Production Manager

Seattle, WA

Stacey Luce, Production Coordinator

Rhonda Kass, Goochland Middle School,

Chris Moraine, Production Specialist

Goochland, VA

Allan Miller, Kenai Middle School, Soldotna, AK

BSCS Administrative Staff

Anna Persson, York International, Thornton, CO

Richard Cardullo, University of California, Riverside,

Kathryn Rice, Beaver Lake Middle School, Issaquah, WA

California, Chair, Board of Directors

Mary Rodriguez, Edwards Elementary School,

Janet Carlson, Executive Director

Chicago, IL

Pam Van Scotter, Associate Director

Katherine Smyre, West Cary Middle School, Cary, NC

Jane Suminski, Humboldt Park K–8 School,

National Institutes of Health

Milwaukee, WI

Stephen Groft, Office of Rare Diseases Research

Mark Temons, Muncy Junior/Senior High School,

David Eckstein, Office of Rare Diseases Research

Williamsport, PA

Geraldine Pollen, Office of Rare Diseases Research

Shannon Thomas, Cocopah Middle School,

Bruce Fuchs, Office of Science Education

Scottsdale, AZ

Lisa Strauss, Office of Science Education

David Vannier, Office of Science Education

Reviewers

Cindy Allen, Office of Science Education

Hal Dietz, Victor A. McKusick Professor of Medicine

and Genetics, Johns Hopkins University School of

Red Hill Studios

Medicine, Baltimore, MD

Bob Hone, Creative Director

Steve Holland, Chief of the Laboratory of Clinical

Sharon Hibbert, Senior Producer

Infectious Diseases, National Institute of Allergy and

Wendy Hari, Producer

Infectious Diseases, Bethesda, MD

Brent Tam, Associate Producer

Christian Kratz, Investigator, National Cancer

Steve McEntee, Designer/Art Director

Institute, Bethesda, MD

Charlie Brown, Senior Programmer

Dave Gonzalez, Programmer

This material is based on work supported by the

John Hoffsis, Programmer

National Institutes of Health under Contract No.
HHSN263200800031C. Any opinions, findings,

Advisory Committee

conclusions, or recommendations expressed in this

Sukirti Bagal, National Organization for Rare

publication are those of the authors and do not

Disorders, Danbury, CT

necessarily reflect the view of the funding agency.

Claireen Espinoza, Taos Day School, Taos, NM

Jennifer Hackett, The Dalton School, New York, NY

Anna Kong, Stone Academy, Chicago, IL

Henrietta List, Community Science Network,

Hanover, ME

Gregory McDonald, Philadelphia College of

Osteopathic Medicine, Philadelphia, PA

Philip Reilly, Independent Consultant, Concord, MA

Colorado Springs, CO 80918-3842.

Design Team

Steven Brügge, Eisenhower Middle School,

Please contact the NIH Office of Science

Albuquerque, NM

Education with questions about this

Samuel Davis, Olympia High School, Orlando, FL

Timothy Garrington, University of Colorado–Denver/

supplement at supplements@science.

Children’s Hospital, Aurora, CO

education.nih.gov.

Contents

Foreword

Rare Diseases and Scientific Inquiry is the most
Each of our curriculum supplements comes
recent addition to the National Institutes of
with a complete set of printed materials for
Health (NIH) Curriculum Supplement Series.
teachers, including extensive background and
This series brings the latest medical science and
resource information, detailed lesson plans,
research discoveries from NIH into the K–12
and masters for student worksheets. The Web
classroom. NIH plays a vital role in the health
site accompanying *Rare Diseases and Scientific*
of all Americans and seeks to foster interest
Inquiry has interactive materials to support the
in research, science, and medicine-related
lessons. The supplements are distributed for
careers for future generations. The NIH Office
free to educators across the United States upon
of Science Education is dedicated to promoting
request. They may be copied for classroom use
scientific literacy and the knowledge and skills
and educational purposes but may not be sold.
we need to secure a healthy future for all.

We welcome your feedback. For a complete list of curriculum supplements and ordering information, or to submit feedback, visit http://science.education.nih.gov or write to us at:

Curriculum Supplement Series
Office of Science Education
National Institutes of Health
6100 Executive Blvd., Suite 3E01
Bethesda, MD 20892-7520

or

supplements@science.education.nih.gov

We appreciate the valuable contributions from science teachers, medical experts, education specialists, scientists, representatives from the NIH Office of Rare Diseases Research (ORDR), and curriculum-design experts from Biological Sciences Curriculum Study (BSCS) created

Rare Diseases and Scientific Inquiry gives students an opportunity to grapple with some of the most challenging and engaging medical issues that confront our society.

We designed *Rare Diseases and Scientific Inquiry* to complement existing life science curricula and to be consistent with *National Science Education Standards.* Middle school

the talented staff at BSCS. We are also grateful
the activities. The collaborative development
to the NIH scientists, advisors, and all other
process includes geographically dispersed field
participating professionals for their work and
tests by teachers and students.
dedication. Finally, we thank the teachers and
students who participated in focus groups and
The curriculum supplements enable teachers
field tests to ensure that these supplements are
to facilitate learning and stimulate student
both engaging and effective. I hope you find our
interest by applying scientific concepts to real-
series a valuable addition to your classroom,
life scenarios. Design elements emphasize key
and I wish you a productive school year.
biology concepts and analytic methods, cutting-
edge science content, and built-in assessment
Bruce A. Fuchs, Ph.D.
tools. Activities promote active and collaborative
Director
learning to help students develop problem-
Office of Science Education
solving strategies and critical-thinking skills.
National Institutes of Health

About the National Institutes of Health

Founded in 1887, NIH is the federal focal point
basic research and clinical investigators, as
for health research in the United States. Today,
well as the myriad professionals in many allied
it is one of the agencies in the Department
disciplines who support the research enterprise.
of Health and Human Services. Its mission is
These efforts also help educate people about
science in pursuit of fundamental knowledge
scientific results so that they can make informed
about the nature and behavior of living systems
decisions about their own—and the public's—
and the application of that knowledge to extend
health.
healthy life and reduce the burdens of illness
and disability. NIH works toward meeting the
This curriculum supplement is one such
mission by providing leadership, direction, and
education effort. It is a collaboration among the
grant support to programs designed to improve
Office of Rare Diseases Research, the NIH Office
the health of the nation through research.
of Science Education, and Biological Sciences

Curriculum Study.

NIH's education programs contribute to ensuring the continued supply of well-trained

For more about NIH, visit http://www.nih.gov .

About the Office of Rare Diseases Research

The Office of Rare Diseases (ORD) was States and several foreign countries working established in 1993 at the National Institutes on about 100 different rare diseases, and is of Health. Later, the ORD's focus on research working to harmonize community efforts on prompted a name change to the Office of Rare patient registries and biospecimen repositories. Diseases Research (ORDR). The ORDR provides A rare disease (also called an "orphan disease") information on rare diseases and rare disease is a condition affecting fewer than 200,000 research; supports scientific conferences; people in the United States (about 1 in 1,500) cosponsors, with the National Human Genome or one affecting more people but "for which Research Institute, the Genetic and Rare no reasonable expectation exists that the costs Diseases Information Center; and coordinates of developing or distributing a drug can be

and supports research on the diagnosis and
recovered from the sale of the drug in the
treatment of rare diseases both intramurally and
United States” (Orphan Drug Act of 1983).
extramurally. The Office also funds the Rare
Diseases Clinical Research Network (RDCRN),
For more about the ORDR, visit
a group of clinical research sites in the United
http://rarediseases.info.nih.gov.

About Biological Sciences Curriculum Study

Headquartered in Colorado Springs, Colorado,
Instructional Model and inquiry are hallmarks
BSCS was founded in 1958 as a curriculum
of its materials, placing students at the center of
study committed to an evidence- and inquiry-
their learning.
based approach to science education. BSCS
instructional materials and professional
The BSCS mission is to transform science
development services are based on current
teaching and learning through research
research about teaching and learning for all
and development that strengthens learning

science classrooms, kindergarten through
environments and inspires a global community
college.
of scientifically literate citizens. BSCS is a
501(c)(3) nonprofit organization.
BSCS’s materials are extensively field-tested
in diverse settings across the country and
For more information, please visit
evaluated for proven effectiveness. The BSCS 5E
http://www.bscs.org.

Introduction to *Rare Diseases*
and Scientific Inquiry

Calling a disease “rare” raises questions. What
2. the process of scientific inquiry through
does it mean to say that a disease is rare? Why
studying rare diseases.
should rare diseases be singled out for special
attention? In the United States, a disease is
The lessons in this supplement help students
considered rare if it affects fewer than 200,000
sharpen their skills in observation, critical
people. Approximately 7,000 rare diseases are
thinking, experimental design, and data
recognized, and researchers continue to describe

analysis. They also make connections to other
new ones. Taken together, rare diseases represent
disciplines such as English, mathematics, and
a significant health concern affecting over
social science.
25 million Americans. Like more-common
diseases, rare diseases may be caused by gene
As the supplement achieves its objectives,
mutations, infection from pathogens, and exposure
it helps convey to students the purpose of
to harmful substances in the environment.
scientific research. Students experience how
science provides evidence that can be used to
Because rare diseases affect fewer people than
understand and treat human disease. Ongoing
common diseases do, they have traditionally
research affects how we understand the world
been allocated fewer research resources. This
around us and gives us the foundation for
has made it more difficult for people with rare
improving choices about our personal health
diseases to obtain accurate diagnoses of their
and the health of our community.
conditions. Even with an accurate diagnosis,
patients may find that there are no existing

The lessons in this supplement encourage
medications or other treatments to help them.
students to think about the relationships among
People with rare diseases may feel isolated and
knowledge, choice, behavior, and human health
even stigmatized. Fortunately, during the past
in this way:
25 years, increased attention has been devoted
Knowledge (what is known and not known)
to the study of rare diseases, and new treatments
+ Choice = Power
are being developed to help patients.
Power + Behavior = Enhanced Human Health

What Are the Objectives of the Supplement?

The final objective of this supplement is to
Rare Diseases and Scientific Inquiry has two
encourage students to think in terms of these
main objectives: to help students in grades 6–8
relationships now and as they grow older.
understand
1. that studying rare diseases is not only

Why Teach the Supplement?

important to the people affected by
Middle school life science classes offer an

the diseases, but it also contributes to
ideal setting for integrating many areas of
understandings that researchers can apply
student interest. In this supplement, students
to other, more-common diseases or, more
participate in activities that integrate inquiry,
generally, to how the body works and
science, human health, mathematics, and

science-technology-society relationships. The
(National Research Council (NRC), 1996). It
real-life context of the supplement's classroom
pays particular attention to the standards on
lessons is engaging for students, and they can
scientific inquiry.
immediately apply what they learn to their lives.
• It is integrated with other subjects, drawing
most heavily from science, social science,

What's in It for the Teacher?

mathematics, and health.
Rare Diseases and Scientific Inquiry meets many
• It has a Web-based technology component that
of the needs of teachers in modern classrooms:
includes interactive activities and simulations.
• The supplement meets science content,

• Finally, the supplement includes built-in teaching, and assessment standards in assessment tools, which we note with an the *National Science Education Standards* assessment icon in each lesson.

Table 1. Correlation of *Rare Diseases and Scientific Inquiry* to Middle School Biology Topics

Topics	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Important levels of biological organization include cells, organs, tissues, organ systems, whole organisms, and ecosystems.					
Specialized cells carry out specialized functions.					
Humans have various body systems including those for digestion, reproduction, circulation, excretion, movement, control and coordination, and protection from disease.					
Body systems interact with each other.					
Every organism requires a set of					

instructions for specifying traits. Heredity is the passage of these instructions from one generation to another.

Hereditary information is contained in genes. An inherited trait of an individual can be determined by one or by many genes. A single gene can influence more than one trait.

The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited, and others result from interactions with the environment.

Natural environments may contain substances and microbes that are harmful to human beings.

In addition, the supplement provides a means problem solve, reason, investigate, and construct for professional development. Teachers can their own meaning for the content.” The use engage in new and different teaching practices of supplemental material like *Rare Diseases and* like those described in this supplement without

Scientific Inquiry can encourage reflection and
completely overhauling their entire program. In
discussion and stimulate teachers to improve
Designing Professional Development for Teachers
their practices by focusing on student learning
of Science and Mathematics, S. Loucks-Horsley
through inquiry.
and coauthors (1998) write that supplements
such as *Rare Diseases and Scientific Inquiry* can
A correlation of the supplement's major
"offer a window through which teachers can get
concepts with the biology and scientific inquiry
a glimpse of what new teaching strategies look
topics often included in the middle school life
like in action." By experiencing a short-term
science curricula follows (Tables 1 and 2). We
supplement like this one, teachers can "change
hope this information helps teachers make
how they think about teaching and embrace
decisions about incorporating this material into
new approaches that stimulate students to
the curriculum.

Table 2. Correlation of *Rare Diseases and Scientific Inquiry* to Middle School Scientific Inquiry Topics

Topics

Lesson 1

Lesson 2

Lesson 3

Lesson 4

Lesson 5

Testable questions can be answered

through scientific investigations.

Scientific investigations use appropriate

tools to gather, analyze, and interpret data.

Evidence is used to develop explanations

and make predictions.

Critical thinking is used to relate evidence

to explanations.

Alternative explanations are recognized

and analyzed.

Mathematics is important to scientific

inquiry.

Implementing the Supplement

We designed the five lessons in this supplement

on rare diseases and the importance of these

to be taught in sequence for approximately

diseases to medicine and to their lives.

10 days, assuming class periods of about

50 minutes. The following pages offer general

Students begin by considering their initial
suggestions about using these materials in the
thoughts about disease, its causes, what makes
classroom; you will find specific suggestions in
a disease rare, and what it might be like to
the procedures of each lesson.
cope with a rare disease (Lesson 1). Students
then explore the three major causes of disease

What Are the Goals of the Supplement?

(genetics, environmental exposure, and
Rare Diseases and Scientific Inquiry is designed to
infectious agents). They focus on the case of
help students attain these major goals associated
an infectious bacterium that can cause both
with scientific literacy:
a common and a rare disease (Lesson 2). We
• to understand a set of basic scientific
use a case study to explain how a rare disease
principles related to the study of rare diseases
is identified and to illustrate the sometimes
and the relationships of rare diseases to
difficult problem of obtaining an accurate
common diseases and human health,
diagnosis (Lesson 3). In Lesson 4, students
• to experience the process of scientific inquiry

investigate how medical research and clinical
and develop an enhanced understanding of
trials have affected the treatment of a rare
the nature and methods of science, and
disease.
• to recognize the role of science in society and
the relationship between basic research and
Lesson 5, the final lesson, gives students an
human health.
opportunity to consider what they have learned
in the previous lessons. The creation of an
What Are the Science Concepts and
informational poster has students reconsider
How Are They Connected?
what they learned about rare diseases: how the
The lessons are organized into a conceptual
diseases are investigated, how medical research
framework that allows students to start with
can affect their treatment, and what it is like to
what they already know about disease and
cope with one. The following chart (Table 3)
scientific inquiry, some of which may be
illustrates the science content and conceptual
incorrect. They then gain a scientific perspective
flow of the classroom lessons and activities.

Table 3. Science Content and Conceptual Flow of the Lessons

Lesson	Learning Focus, Major Concepts from BSCS 5E Instructional Model
Lesson 1—Engage What Is a Rare Disease?	Students may have different ideas about the definition of “disease.” They may also have naïve preconceptions about what makes a disease rare and how rare diseases are treated, and they may have attitudes about people with rare diseases.
Lesson 2—Explore What Causes Rare Diseases?	Diseases have three main causes: genetics, environmental exposure, and infectious agents. These three influences sometimes interact with each other. An infectious agent may be able to cause a common disease in one case and a rare disease in another

case. Doctors must ask testable questions and collect evidence to answer such questions when coming to a diagnosis.

Lesson 3—

Explain

Some rare diseases are inherited. A rare disease may

The Difficulty of

affect multiple body systems. Rare diseases sometimes

Diagnosis

share symptoms with more-common diseases, which can make getting a proper diagnosis difficult. People with a rare disease must sometimes cope with a stigma associated with being different from others.

Lesson 4—

Elaborate

A karyotype can provide evidence that a disease has

The Importance of

a genetic cause. Some genetic diseases are inherited,

Medical Research

while others are not. Much medical information is available online, but not all of it is useful or reliable. Clinical trials are an application of the scientific method to medicine. They have helped improve treatments for many rare diseases.

Lesson 5—

Evaluate

Patient support groups, government agencies, and

Communicating

other organizations exist to provide reliable information

about Rare

about rare diseases to the public. Knowledge about

Diseases

rare diseases and their impacts on people's lives may

reduce the stigma sometimes associated with having a

rare disease.

How Does the Supplement Correlate

Research Council's 1996 *National Science*

to the *National Science Education*

Education Standards (*NSES*). The content of

***Standards*?**

the supplement is explicitly standards based.

Rare Diseases and Scientific Inquiry supports

The following chart (Table 4) lists the specific

teachers in their efforts to reform science

content standards that this supplement

education in the spirit of the National

addresses.

Table 4. Alignment of *Rare Diseases and Scientific Inquiry* Lessons with *National*

***Science Education Standards* for Content, Grades 5–8**

Table 4a.* NSES *Standard A, Science as Inquiry

As a result of activities in grades 5–8, all students should develop

Correlation to *Rare*

Diseases and Scientific

Inquiry Lessons

Abilities necessary to do scientific inquiry

1, 2, 3, 4

• Identify questions that can be answered through scientific investigations.

1, 2, 3, 4

• Design and conduct a scientific investigation. Students should develop 4

general abilities, such as systematic observation, making accurate

measurements, and identifying and controlling variables.

• Use appropriate tools and techniques to gather, analyze, and interpret 2, 3, 4

data.

• Develop descriptions, explanations, predictions, and models using

1, 2, 3, 4

evidence. Students should base their explanations on what they

observed, and as they develop cognitive skills, they should be able to

differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument.

• Think critically and logically to make the relationships between evidence 2, 3, 4

and explanations.

• Recognize and analyze alternative explanations and predictions.

2, 3, 4

• Communicate scientific procedures and explanations.

2, 3, 4

• Use mathematics in all aspects of scientific inquiry.

3, 4

Understandings about scientific inquiry

2, 3, 4, 5

• Different kinds of questions suggest different kinds of scientific

2, 3, 4

investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.

• Mathematics is important in all aspects of scientific inquiry.

3, 4

• Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.

2, 3, 4, 5

• … Asking questions and querying other scientists' explanations is part of scientific inquiry.

2, 3, 4, 5

Table 4b. **NSES** ***Standards C, F, and G, Life Science, Science in Personal and Social Perspectives, and History and Nature of Science***

As a result of activities in grades 5–8, all students should develop understanding of	Correlation to *Rare*

Diseases and Scientific

Inquiry Lessons

Standard C. Structure and Function in Living Systems

All

• … Different tissues are … grouped together to form larger functional

2, 3, 4

units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.

• The human organism has systems for digestion, respiration, reproduction, 2, 3, 4

circulation, excretion, movement, control, and coordination, and for

protection from disease. These systems interact with each other.

• Disease is a breakdown in structures or functions of an organism.

All

Standard C. Reproduction and Heredity

2, 3, 4

• Every organism requires a set of instructions for specifying its traits. Heredity 2, 3, 4

is the passage of these instructions from one generation to another.

• The characteristics of an organism can be described in terms of a

3, 4

combination of traits. Some are inherited, and others result from

interactions with the environment.

• Hereditary information is contained in genes, located in the

4

chromosomes of each cell. Each gene carries a single unit of

information. An inherited trait of an individual can be determined by

one or by many genes, and a single gene can influence more than

one trait. A human cell contains many thousands of different genes.

Standard F. Personal Health

1, 2, 4

• Natural environments may contain substances (for example, radon and

1, 2, 4

lead) that are harmful to human beings.

Standard F. Risks and Benefits

1, 2, 3, 4

• Students should understand the risks associated with natural hazards

1, 2, 4

(fires, floods, tornadoes, hurricanes, earthquakes, and volcanic

eruptions), with chemical hazards (pollutants in air, water, soil, and

food), biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and personal hazards

(smoking, dieting, and drinking).

• Individuals can use a systematic approach to thinking critically about 3, 4

risks and benefits.

Standard G. Nature of Science

• Scientists formulate and test their explanations of nature using

2, 3, 4

observation, experiments, and theoretical and mathematical models.

• It is part of scientific inquiry to evaluate the results of scientific 2, 3, 4, 5

investigations, experiments, observations, theoretical models, and the

explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and

suggesting alternative explanations for the same observations.

Teaching Standards

How Does the BSCS 5E Instructional

Model Promote Active, Collaborative,

Inquiry-Based Learning?

The suggested teaching strategies in all the lessons support educators as they work to meet the teaching standards outlined in the *National Science Education Standards* (NRC, 1996).

The lessons in this supplement use a research-based pedagogical approach called the BSCS 5E Instructional Model, or the BSCS 5Es. The BSCS 5Es are based on a **constructivist** theory of learning. A key premise of this theory is that students are active thinkers who build (or construct) their own understanding of concepts out of interactions with phenomena, term objectives for students. It also includes planning tools such as the Science Content and Conceptual Flow of the Lessons chart (Table 3) and a suggested timeline for teaching the supplement (page 18). Teachers can use

This supplement helps science teachers plan an inquiry-based program by providing short-

the environment, and other individuals.

the supplement to update their curriculum

A constructivist view of science learning

in response to their students' interest in this

recognizes that students need time to

topic. The focus on active, collaborative, and

• express their current thinking;

inquiry-based learning helps teachers support

• interact with objects, organisms, substances,

the development of student understandings and

and equipment to develop a range of

nurture a community of science learners.

experiences on which to base their thinking;

• reflect on their thinking by writing and

The structure of the lessons enables teachers to

expressing themselves and comparing what

guide and facilitate learning. All the activities

they think with what others think; and

encourage and support student inquiry, promote

• make connections between their learning

discourse among students, and challenge

experiences and the real world.

students to accept and share responsibility for

their learning. Using the BSCS 5E Instructional

The three key findings related to student

Model, combined with active, collaborative
learning identified in *How People Learn*
learning, allows teachers to respond effectively
(Bransford et al., 2000), a comprehensive
to the diversity of student backgrounds and
review of research on learning, support
learning styles. The supplement is fully
the pedagogical strategies promoted by
annotated, with suggestions for how teachers
implementing the BSCS 5Es:
can encourage and model the skills of
• Students enter class with a variety
scientific inquiry, as well as foster the curiosity,
of preconceptions that may later
skepticism, and openness to new ideas and data
significantly interfere with learning if
that characterize the successful study of science.
those preconceptions are not engaged and
addressed.

Assessment Standards

• To develop competence in a given subject,
Teachers can engage in ongoing assessment of
students must build a strong foundation of
their teaching and of student learning by using
factual knowledge within the context of a

the assessment components embedded in each
coherent conceptual framework.
lesson. The assessment tasks are authentic;
• Students benefit from a metacognitive
they are similar in form to tasks that students
approach to learning that emphasizes goal
will engage in outside the classroom or that
setting and self-monitoring.
scientists do. Annotations guide teachers to
these opportunities for assessment and provide
The BSCS 5Es sequence the learning
answers to questions that can help teachers
experiences so that students can construct
analyze students' feedback.
their own understanding of a science concept
Implementing the Supplement

over time. The model leads students through
Explore
five phases of active learning that are easily
In the Explore phase of the supplement
described using five words that begin with the
(Lesson 2), students investigate a variety of
letter *E*: Engage, Explore, Explain, Elaborate,
medical problems and consider possible causes

and Evaluate. Rather than just listening and
for each. Students interact with medical reports,
reading, students are also analyzing and
assess which problems pose the biggest risks,
evaluating evidence, experiencing, and talking
and act accordingly. The lesson allows students
with their peers in ways that promote the
to express their developing understanding of rare
development and understanding of key science
diseases and scientific inquiry through analyzing
concepts. These inquiry-based experiences
and comparing data, analyzing hypothetical
include both direct experimentation and
situations, and answering questions.
development of explanations through critical
and logical thinking. Students often use

Explain

technology to gather evidence, and mathematics
The Explain phase provides opportunities for
to develop models or explanations.
students to connect their previous experiences
and begin to make conceptual sense of the main
The BSCS 5Es emphasize student-centered
ideas of the supplement. It also allows you to
teaching practices. Students participate in their

introduce formal language, scientific terms, and
learning in ways that are different from those
content information that might make students'
seen in a traditional classroom. The following
previous experiences easier to describe and
charts exemplify what teachers do (Table 5)
explain.
and what students do (Table 6) in the BSCS 5E
Instructional Model.
In the Explain phase (Lesson 3), students
investigate a case study dealing with **Marfan**
The following paragraphs illustrate how we
syndrome. Students
implemented the BSCS 5Es in *Rare Diseases and*
• explain, in their own words, concepts and
Scientific Inquiry.
ideas about the causes of rare diseases;
• listen to and compare others' explanations of
Engage
the results with their own;
Students come to learning situations with
• become involved in student-to-student
prior knowledge. The Engage lesson gives you
discourse in which they explain their
the chance to find out what students already

thinking to others and debate their ideas;

know or think they know about the topic and

• record their ideas and current

concepts to be developed.

understandings; and

• revise their ideas.

The Engage phase of this supplement

(in Lesson 1) is designed to

Elaborate

• pique students' curiosity and generate

In the Elaborate lesson (Lesson 4), students

interest;

make conceptual connections between new

• determine students' current understandings

and previous experiences. They draw on their

about disease, the scientific study of disease,

knowledge about rare diseases and scientific

and their attitudes toward disease;

inquiry to investigate how medical research can

• encourage students to compare their ideas

help doctors diagnose and improve treatments

with those of others; and

for a rare disease. In this lesson, students

• give you a chance to hear or read students'

• connect ideas and apply their understandings

current conceptions, which you can address

of rare diseases and scientific inquiry to the

in the later lessons.

treatment of childhood **leukemia**,

10

Rare Diseases and Scientific Inquiry

Table 5. Understanding the BSCS 5E Instructional Model: What the Teacher Does Phase

Consistent with the BSCS 5E

Inconsistent with the BSCS 5E

Instructional Model

Instructional Model

Engage

• Piques students' curiosity and generates

• Introduces vocabulary

interest

• Explains concepts

• Determines students' current understanding

• Provides definitions and answers

(prior knowledge) of a concept or idea

• Provides closure

• Invites students to express what they think

• Discourages students' ideas and

• Invites students to raise their own questions

questions

Explore

• Encourages student-to-student interaction

• Provides answers

• Observes and listens to the students as they

• Proceeds too rapidly for students to

interact

make sense of their experiences

• Asks probing questions to help students

• Provides closure

make sense of their experiences

• Tells the students that they are wrong

• Provides time for students to puzzle through

• Gives information and facts that solve

problems

the problem

• Leads the students step-by-step to a

solution

Explain

• Encourages students to use their common

• Neglects to solicit students'

experiences and data from the Engage and

explanations

Explore lessons to develop explanations

• Ignores data and information

• Asks questions that help students express

students gathered from previous

understanding and explanations

lessons

• Requests justification (evidence) for students’

• Dismisses students’ ideas

explanations

• Accepts explanations that are not

• Provides time for students to compare their

supported by evidence

ideas with those of others and perhaps to

• Introduces unrelated concepts or

revise their thinking

skills

• Introduces terminology and alternative

explanations after students express their ideas

Elaborate

• Focuses students’ attention on conceptual

• Neglects to help students connect

connections between new and former

new and former experiences

experiences

• Provides definitive answers

• Encourages students to use what they have

• Tells students that they are wrong

learned to explain a new event or idea

• Leads students step-by-step to a

• Reinforces students' use of scientific terms

solution

and descriptions previously introduced

• Asks questions that help students draw

reasonable conclusions from evidence and

data

Evaluate

• Observes and records as students

• Tests vocabulary words, terms, and

demonstrate their understanding of

isolated facts

concept(s) and performance of skills

• Introduces new ideas or concepts

• Provides time for students to compare their

• Creates ambiguity

ideas with those of others and perhaps to

• Promotes open-ended discussion

revise their thinking

unrelated to the concept or skill

• Interviews students as a means of assessing

their developing understanding

• Encourages students to assess their own

progress

Implementing the Supplement

Table 6. Understanding the BSCS 5E Instructional Model: What the Students Do Phase

Consistent with the BSCS 5E

Inconsistent with the BSCS 5E

Instructional Model

Instructional Model

Engage

• Become interested in and curious about

• Ask for the “right” answer

the concept/topic

• Offer the “right” answer

• Express current understanding of a concept

• Insist on answers or explanations

or idea

• Seek closure

• Raise questions such as, What do I already

know about this? What do I want to know

about this? How could I find out?

Explore

• Use materials and ideas

• Let others do the thinking and

• Conduct investigations in which they

exploring (passive involvement)

observe, describe, and record data

• Work quietly with little or no interaction

• Try different ways to solve a problem or

with others (only appropriate when

answer a question

exploring ideas or feelings)

• Acquire a common set of experiences so

• Stop with one solution

they can compare results and ideas

• Demand or seek closure

• Compare their ideas with those of others

Explain

• Explain concepts and ideas in their own

• Propose explanations from “thin

words

air” with no relationship to previous

• Base their explanations on evidence

experiences

acquired during previous investigations

• Bring up irrelevant experiences and

• Record their ideas and current

examples

understanding

• Accept explanations without

• Reflect on and perhaps revise their ideas

justification

• Express their ideas using appropriate

• Ignore or dismiss other plausible

scientific language

explanations

• Compare their ideas with what scientists

• Propose explanations without evidence

know and understand

to support their ideas

Elaborate

• Make conceptual connections between

• Ignore previous information or

new and former experiences

evidence

• Use what they have learned to explain a

• Draw conclusions from “thin air”

new object, event, organism, or idea

• Use terminology inappropriately and

• Use scientific terms and descriptions

without understanding

• Draw reasonable conclusions from

evidence and data

• Communicate their understanding to others

• Demonstrate what they understand about

the concept(s) and how well they can

implement a skill

Evaluate

• Compare their current thinking with that of

• Disregard evidence or previously

others and perhaps revise their ideas

accepted explanations in drawing

• Assess their own progress by comparing

conclusions

their current understanding with their prior

• Offer only yes-or-no answers or

knowledge

memorized definitions or explanations

• Ask new questions that take them deeper

as answers

into a concept or topic area

• Fail to express satisfactory explanations

in their own words

• Introduce new, irrelevant topics

• use and understand scientific terms and

supplement *Sleep, Sleep Disorders, and Biological*

descriptions accurately and in context,

Rhythms, developed by BSCS in 2003 (NIH and

• draw reasonable conclusions from evidence

BSCS, 2003). Sixty high school students and

and data,

one teacher participated. The students were

• add depth to their understandings of rare

randomly assigned to either the experimental

diseases and scientific inquiry, and

or the control group. In the experimental

• communicate their understandings to others.

group, the teacher used a version of the sleep

supplement that was closely aligned with the

Evaluate

theoretical underpinnings of the BSCS 5Es.

The Evaluate lesson is the final phase of the

For the control group, the teacher used a set

instructional model, but it only provides a

of lessons based on the science content of the

“snapshot” of what the students understand

sleep supplement but aligned with the most

and how far they have come. In reality,

commonplace instructional strategies found

the assessment of students’ conceptual

in U.S. science classrooms (as documented by

understanding and ability to use skills begins

Weiss et al., 2003). Both groups had the same

with the Engage lesson and continues through
master teacher.
each of the other phases. Combined with the
students' written work and performance of
Students taught with the BSCS 5Es and
tasks throughout the supplement, however,
an inquiry-based approach demonstrated
the Evaluate lesson can serve as a summative
significantly higher achievement for a range of
assessment of what students know and can do.
important learning goals, especially when the
results were adjusted for variance in pretest
The Evaluate lesson (Lesson 5) gives students
scores. The results were also consistent across
a chance to
time (both immediately after instruction and
• demonstrate their understandings of rare
four weeks later). Improvements in student
diseases and scientific inquiry,
learning were particularly strong for measures
• share their current thinking with others,
of student reasoning and argumentation. The
• assess their own progress by comparing their
following chart (Table 7) highlights some of
current understandings with their initial

the study's key findings. The results of the

ideas, and

experiment strongly support the effectiveness of

• ask questions that take them deeper into a

teaching with the BSCS 5Es.

concept.

Evidence also suggests that the BSCS 5Es

What's the Evidence for the Effectiveness

are effective in changing students' attitudes

of the BSCS 5E Instructional Model?

on important issues. In a research study

Support from educational research studies for

conducted during the field test for the NIH

teaching science as inquiry is growing (for

curriculum supplement *The Science of Mental*

example, Geier et al., 2008; Hickey et al., 1999;

Illness (NIH and BSCS, 2005), BSCS partnered

Lynch et al., 2005; and Minner et al., 2009).

with researchers at the University of Chicago

A 2007 study, published in the *Journal of*

and the National Institute of Mental Health.

Research in Science Teaching (Wilson et al.,

The study investigated whether a short-term

2010), is particularly relevant to the *Rare*

educational experience would change students'

Diseases and Scientific Inquiry supplement.

attitudes about mental illness. The results

showed that after completing the curriculum

In 2007, with funding from NIH, BSCS

supplement, students stigmatized mental illness

conducted a randomized, controlled trial

less than they had beforehand. The decrease in

to assess the effectiveness of the BSCS 5Es.

stigmatizing attitudes was statistically significant

The study used an adaptation of the NIH

(Corrigan et al., 2007; Watson et al., 2004).

Implementing the Supplement

Table 7. Differences in Performance of Students Receiving Inquiry-Based and Commonplace Instructional Approaches

Measure

Mean for Students

Mean for Students

Effect Size

Receiving

Receiving Inquiry-

Commonplace

Based Teaching

Teaching

Total test score pretest (out of 74)

31.11

29.23

Not applicable

Total test score posttest

42.87

47.12

0.47

Reasoning pretest (fraction of

0.04

0.03

Not applicable

responses at the highest level)

Reasoning posttest (fraction of

0.14

0.27

0.68

responses at the highest level)

Score for articulating a claim

1.58

1.84

0.58

(out of 3)

Score for using evidence in an

1.67

2.01

0.74

explanation (out of 3)

Score for using reasoning in an

1.57

1.89

0.59

explanation (out of 3)

Source: C.D. Wilson et al. 2010. The relative effects and equity of inquiry-based and commonplace science teaching on students' knowledge, reasoning, and argumentation. *Journal of Research in Science and Teaching, 47(3),* 276–301.

Note: Effect size is a convenient way of quantifying the amount of difference between two treatments. This study used the standardized mean difference (the difference in the means divided by the standard deviation, also known as Cohen's *d*). The posttest scores controlled for the variance in students' pretest scores. The reasoning posttest scores controlled for variance in students' reasoning pretest scores at the highest level.

How Does the Supplement Support

These strategies allow you to assess a variety

Ongoing Assessment?

of aspects of the learning process, such

Teachers will use this supplement in a variety of

as students' prior knowledge and current

ways and at different points in their curriculum.

understandings, problem-solving and critical-

The most appropriate way to assess student

thinking skills, level of understanding of new

learning occurs informally at various points

information, communication skills, and ability

within the five lessons, rather than just once,

to synthesize ideas and apply understanding to

formally, at the end. We integrated assessment

a new situation.

components within the lessons. These

“embedded” assessment opportunities include

How Can Controversial Topics Be Handled

one or more of the following strategies:

in the Classroom?

• performance-based activities, such as

Teachers sometimes feel that the discussion of

developing graphs or participating in a

values is inappropriate in the science classroom

discussion of health effects or social policies;

or that it detracts from the learning of “real”

• oral presentations to the class, such as

science. The lessons in this supplement,

reporting experimental results; and

however, are based on the conviction that

• written assignments, such as answering

much can be gained by involving students in

questions or writing about demonstrations

analyzing issues of science, behavior, health,

and society. Society expects all citizens to

• Emphasize that everyone must be open to

participate in the democratic process, and
hearing and considering diverse views.
our educational system must give students
• Use unbiased questioning to help students
opportunities to learn to deal with contentious
critically examine all views presented.
issues with civility, objectivity, and fairness.
• Allow for the discussion of all feelings and
Likewise, students need to learn that science
opinions.
intersects with life in many ways.
• Avoid seeking consensus on all issues. The
multifaceted issues that students discuss
In this supplement, students discuss, interpret,
result in the presentation of divergent
and evaluate basic science and health issues,
views, and students should learn that this is
some in light of their values and ethics. As
acceptable.
students encounter issues they feel strongly
• Acknowledge all contributions in the same
about, some discussions might become
evenhanded manner. If a student seems to
controversial. The degree of controversy will
be saying something for its shock value,

depend on many factors, such as how similar
see whether other students recognize the
the students are with respect to socioeconomic
inappropriate comment, and then invite them
status, perspectives, value systems, and religious
to respond.
preferences. In addition, the language and
• Create a sense of freedom in the classroom.
attitude of the teacher factor into the flow of
Remind students, however, that freedom
ideas and the quality of exchange among the
implies the responsibility to exercise that
students.
freedom in ways that generate positive results
for all.
The following guidelines may help you facilitate
• Insist on a nonhostile environment in the
discussions that balance factual information
classroom. Remind students to respond to
with feelings:
ideas instead of to the individuals presenting
• Remain neutral. Neutrality may be the single,
those ideas.
most important characteristic of a successful
• Respect silence. Reflective discussions are

discussion facilitator.

often slow. If a teacher breaks the silence,

• Encourage students to discover as much

students may allow the teacher to dominate

information about the issue as possible.

the discussion.

• Keep the discussion relevant and moving

• At the end of the discussion, ask students

forward by questioning or posing appropriate

to summarize the points that they and their

problems or hypothetical situations.

classmates have made. Respect students

Encourage everyone to contribute, but do not

regardless of their opinions about any

force reluctant students into the discussion.

controversial issue.

Implementing the Supplement

Using the Student Lessons

The heart of *Rare Diseases and Scientific Inquiry*

• **Materials:** Lists all the materials other than

is a set of five classroom lessons that allow

photocopies that you need for each activity in

students to discover important concepts related

the lesson.

to rare diseases and scientific inquiry. To review

• **Preparation:** Outlines what you need to do

these concepts in detail, refer to the Science

to be ready to teach the activities.

Content and Conceptual Flow of the Lessons

chart (Table 3), found on page 6.

Procedure outlines the steps in each activity

and provides implementation hints and answers

Format of the Lessons

to discussion questions.

As you review the lessons, you will find that

each contains several major features.

The **Lesson Organizer** briefly summarizes the

lesson. It outlines procedural steps for each

At a Glance summarizes the lessons with these

activity and includes icons that notify you when

sections:

masters, transparencies, and the Web site are

• **Overview:** Provides a short summary of

used. You should use the lesson organizer only

student activities.

after you become familiar with the detailed

• **Major Concepts:** Lists the central ideas the

procedures for the activities. It can be a handy

lesson is designed to convey.

resource during lesson preparation as well as

• **Objectives:** Lists specific understandings

during classroom instruction.

or abilities students should have after

completing the lesson.

The **Masters** to be photocopied (student

• **Teacher Background:** Specifies which

worksheets and reference materials) are found at

portions of the background section,

the back of the supplement.

Information about Rare Diseases and

Scientific Inquiry, relate directly to the lesson.

Icons appear throughout the lessons. They

We do *not* intend for this reading material

alert you to teaching aids that can help you
to form the basis of lectures to students,
implement the activities and enrich student
nor do we intend it to be a direct resource
learning.
for students. Rather, it enhances your
Indicates steps that you can use as
understanding of the content so that you can
assessments, including informal
facilitate class discussions, answer student
indicators of student understanding,
questions, and provide additional examples.
and the final assessment at the end
of each lesson.

In Advance provides lists of items and
preparations needed for the activities:
Identifies the teaching strategies

• **Web-Based Activities:** Tells you which of
that address specific science
the lesson's activities use the *Rare Diseases*
content standards as defined by the
and Scientific Inquiry Web site as the basis for
National Science Education
instruction.
Standards (NRC, 1996).

• **Photocopies:** Lists the paper copies and overhead transparencies that you need to make from the masters provided at the end of the supplement.

Using the Student Lessons

Shows when to use the Web site

Identifies suggestions from field-

as part of the teaching strategy.

test teachers for teaching strategies,

A print-based alternative to each

classroom management, and

Web-based activity is provided for

supplement implementation.

classrooms that don’t have Internet

access.

Timeline for Teaching the Supplement

The timeline below (Table 8) outlines the optimal

Identifies a print-based alternative

plan for completing the five lessons. It assumes to a Web-based activity.

you will teach the activities on consecutive days of 50-minute class periods. If your class requires more time for discussing issues raised in this supplement or for completing activities, adjust your timeline accordingly.

Table 8. Suggested Timeline

Timeline	Activity
3 weeks ahead	Reserve computers.
	Check performance of Web site.
7 days ahead	Make photocopies and transparencies.
	Gather materials.
School day 1	**Lesson 1**
	Activity 1: What Is a Rare Disease?
School day 2	**Lesson 2**
	Activity 1: Causes of Disease
	Activity 2: Is a Rare Disease Present?
School day 3	**Lesson 2**

Activity 2: Is a Rare Disease Present?

Activity 3: How Rare Is Rare?

School day 4

Lesson 3

Activity 1: A Parent’s Dilemma

Activity 2: Connective Tissue

School day 5

Lesson 3

Activity 3: A Common Thread

School day 6

Lesson 4

Activity 1: An Unwelcome Diagnosis

School day 7

Lesson 4

Activity 1: An Unwelcome Diagnosis (conclude)

School day 8

Lesson 4

Activity 2: Clinical Trials

School day 9

Lesson 5

Activity 1: Creating an Informational Poster

School day 10

Lesson 5

Activity 2: Reflecting on Rare Diseases

Rare Diseases and Scientific Inquiry

Using the Web Site

The Web site for *Rare Diseases and Scientific* and analysis that the Web site was designed to *Inquiry* can help you organize your use of the stimulate. Group members not involved directly supplement, engage student interest in learning, may become bored or lose interest.
and orchestrate and individualize instruction as learning is taking place. Lessons 2, 3, 4, and 5 We recommend that you keep students in the have activities on the Web site for classrooms same collaborative groups for all the activities with online access. To access the site, go to in the lessons. This will allow each group to http://science.education.nih.gov/supplements/ develop a shared experience with the Web site rarediseases.
and with the ideas and issues the activities present. A shared experience will also enhance Under “Web Portion of Student Activities,” your students’ perceptions of the lesson as a click on the link to a specific lesson. (If your conceptual whole.
classes don’t have access to the site, you can

use the print alternatives included with the

If your student-to-computer ratio is greater than

lessons.)

four to one, you will need to change the way

you teach the supplement from the instructions

Hardware and Software Requirements

in the lessons.

The Web site can be accessed with any

computer browser. To experience full

Web Materials for People with

functionality of the site, Adobe Flash Player

Disabilities

must be installed on the hard drive of each

The Office of Science Education (OSE)

computer that will access the site (available for

provides access to the Curriculum Supplement

free at http://get.adobe.com/flashplayer/).

Series for people with disabilities. The online

versions of this series comply with Section 508

Collaborative Groups

of the Rehabilitation Act. If you use assistive

We designed all the activities in this

technology (such as a Braille or screen reader)

supplement to be completed by teams of

and have trouble accessing any materials on

students working together. Although individual
our Web site, please let us know. We will need a
students working alone can complete many of
description of the problem, the format in which
the steps, this strategy will not stimulate the
you would like to receive the material, the URL
types of student-student interactions that are part
of the requested material, and your contact
of active, collaborative, inquiry-based learning.
information.

Therefore, we recommend that you organize
collaborative groups of two to four students

Contact us at

each, depending on the number of computers

Curriculum Supplement Series

available. Students in groups larger than this

Office of Science Education

will have difficulty organizing student-computer

National Institutes of Health

interactions equitably. This can lead to one or

6100 Executive Boulevard

two students assuming the primary responsibility

Suite 3E01, MSC7520

for the computer-based work. Although large

Bethesda, MD 20892-7520

groups can be efficient, they do not allow all

or

students to experience the in-depth discovery

Information about Rare

Diseases and Scientific Inquiry

1.0 A History of Rare Diseases

concentrated in the world’s poorest countries.

in the United States

Examples of neglected diseases include the

An axiom taught in medical schools around

following:

the world goes like this: When you hear

• Leishmaniasis, a parasitic disease affecting

hoofbeats, think horses, not zebras. We don’t

about 12 million people worldwide and

want future physicians thinking about the most

found, rarely, in the United States among

fanciful possibilities when they see a patient.

people who have been traveling (World

We want them to start with the most obvious

Health Organization, 2009).

diagnosis. Many potential diagnoses are so rare

• Dengue fever, a disease caused by

that most doctors will never see a patient with
a virus transmitted through a mosquito
any of them. Rare diseases (that is, the zebras)
bite. It affects about 50 million to
do occur, though, and physicians must keep
100 million people worldwide but is
them in the back of their minds as they try to
very rare in the United States (Centers
determine what is actually wrong with their
for Disease Control and Prevention (CDC),
patients. This is why the Office of Rare Diseases
2009).
Research has unofficially adopted the zebra as
• Schistosomiasis, a parasitic disease
its mascot.
affecting multiple organs. It affects an
estimated 200 million people worldwide
In the United States, a disease is considered
and is not found in the United States
rare if it affects fewer than 200,000 Americans
(CDC, 2008).
(Institute of Medicine (IOM), 2010). Some rare
diseases, such as cystic fibrosis and Tourette’s
A disease is sometimes described as having a
syndrome, are relatively well known to the

trajectory, meaning that the number of people
public, but most are not. About 7,000 rare
affected by the disease changes through time.
diseases have been identified, and researchers
This means that a rare disease may become
continue to describe new ones. Many affect
common, and a common disease may become
fewer than 1,000 people in the United States,
rare. For example, AIDS was once a rare disease,
but taken together, they represent a significant
but as HIV infection spread around the world,
health concern affecting an estimated
it became a common disease. Effective disease
25 million (ORDR, 2009). The majority of
prevention programs can turn a once-common
rare diseases are caused by gene mutations,
disease into a rare one. This has happened to
but they can also be caused by infection from
diseases such measles and mumps through
pathogens and exposure to environmental
childhood vaccination programs. Healthcare
toxins.
professionals are concerned that some currently
rare diseases may become common due to the
A smaller number of diseases are called

spread of drug-resistant pathogens and public

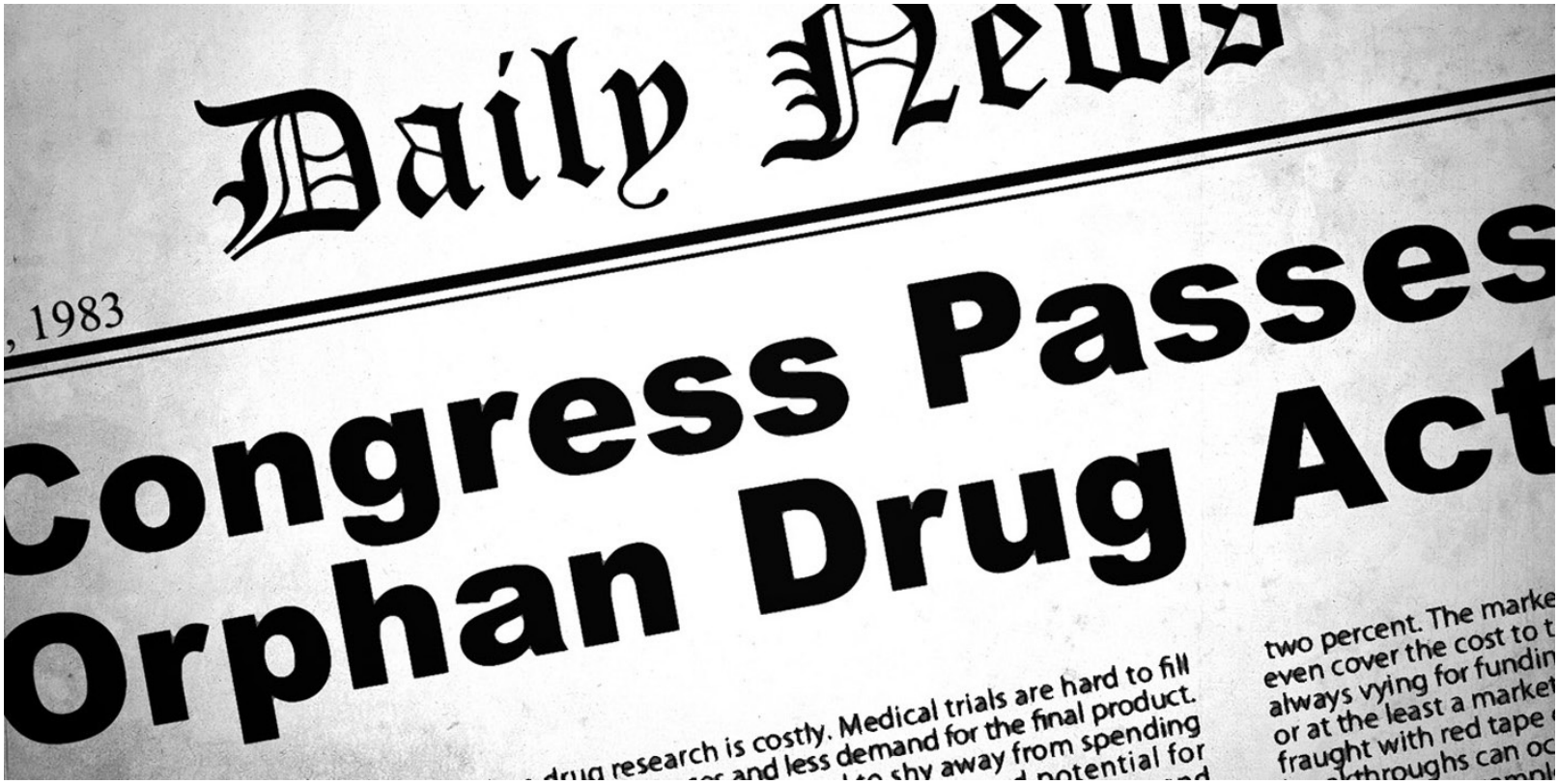
“neglected diseases.” This term is often applied

opposition to childhood vaccinations

to tropical infections that are overwhelmingly

(IOM, 2010).

21



Patients and their families dealing with rare

visibility of rare diseases and resources devoted

diseases face obstacles beyond coping with the

to them gave us the opportunity to develop a

diseases themselves (Rados, 2003):

curriculum supplement that allows students to

• Many patients experience the frustration

gain an understanding of the concept of rare

of not being able to obtain an accurate

diseases and how they are studied. To appreciate
diagnosis. For approximately one-third of
the advances made in the area of rare diseases
patients with a rare disease, correct diagnosis
since 1980, it’s helpful to look at a brief history
takes between one and five years. In Europe,
of the field.
researchers analyzed surveys from over
6,000 patients involving eight rare diseases,
Because each rare disease affects so few people,
including Marfan syndrome, cystic fibrosis,
pharmaceutical companies reasoned that it was
and Duchenne’s muscular dystrophy. Over
not cost effective to develop drugs to treat them.
40 percent of the respondents indicated that
Because those companies were not interested
their first diagnosis was wrong, and
in “adopting” the research needed to develop
25 percent reported that it took between
drugs, the lack of attention to rare diseases led
5 and 30 years to obtain a correct diagnosis
to the terms “orphan diseases” and, for the
(Faurisson, 2004).
drugs needed to treat them, “orphan drugs.”
• Patients often feel isolated and don’t know

In the United States, this situation began to
anyone else who is dealing with the same
change in the 1980s. The Food and Drug
disease.
Administration (FDA) established the Office
• Many patients must travel long distances to
of Orphan Products Development (OOPD). Its
reach appropriate medical care.
aim is to identify and support the development
• The cost of diagnosis and treatment can be
of orphan drugs and biologic products needed
very expensive.
to treat rare diseases. To carry out its mission,
• There may be no medications or other
the OOPD works in collaboration with other
treatments for the disease.
stakeholders such as the research community,
academia, rare disease organizations, and
Until the mid-1980s or so, the study of rare
pharmaceutical companies.
diseases was a low priority for the medical
community. Since then, however, researchers
Congress passed the Orphan Drug Act (ODA) in
have focused more attention on rare diseases
1983. The ODA helps foster the development of

for reasons we explain below. The increased

orphan drugs by providing financial incentives

Figure 1. *Congress stimulated research on rare diseases by passing the Orphan Drug Act.*

to pharmaceutical companies. A medication

ORDR helped fund the Rare Diseases Clinical

that has orphan drug status must meet the

Research Network (RDCRN). It consisted

same safety and efficacy standards as other

originally of 10 research consortia and a Data

drugs. A company working on an orphan drug

and Technology Coordinating Center; by 2009,

receives tax credits and a seven-year period to

the Network had grown to 19 consortia plus a

exclusively market the drug when it’s ready.

Data Management and Coordination Center. The

In the 10 years before the ODA, only 10 drugs

network has conducted or is conducting about

aimed at rare diseases were privately developed.

100 studies across the United States and several

Since then, the FDA has approved more than

other countries. Each consortium focuses on a

350 orphan drug applications. Drugs aimed at

group of medically related rare diseases.

rare diseases accounted for over 30 percent of
the innovative drug applications approved by
Although many rare diseases have no effective
the FDA from 2004 to 2008 (Coté, 2009).
treatment options, medical research is producing
tangible benefits for many patients and their
Medical devices intended to treat patients
families. During the 1960s, people with cystic
with rare diseases are not clearly addressed
fibrosis had a life expectancy of fewer than
by the ODA. In 1996, the FDA created the
10 years. Today, people with the disease can
Humanitarian Device Exemption (HDE)
expect to live to nearly 40 years (Cystic Fibrosis
provision of the Safe Medical Devices Act
Foundation, 2008). A 2008 review of treatments
of 1990. It allows the expedited approval of
for 65 rare diseases revealed that between 1983
a medical device for treating a rare disease
and 2008,
provided that the device is safe and is likely to
• the number of diseases with no treatment
benefit patients. This approval can be granted
options decreased from 31 to 17 and
without costly clinical studies. From 1996 to

• the number of diseases that fully responded
2003, the OOPD gave out 32 HDEs (Rados,
to treatment increased from 8 to 20
2003). One example of where the provision
(Campeau et al.).
has had an impact is in the rare placental
disorder twin-to-twin transfusion syndrome.
Attention to rare diseases has grown since
Blood vessels often connect the circulation of
the 1980s through the efforts of nonprofit
developing twins, and sometimes this leads to
organizations and foundations, some of which
one twin receiving more blood flow than the
were created by people affected by rare diseases
other. A device approved through the HDE
(Rados, 2003). For example, Brad and Vicki
provision allows physicians to identify blood
Margus had two boys with ataxia-telangiectasia
vessels that connect the twins in utero and
(A-T), a fatal genetic disorder that involves the
then normalize the blood flow in those
loss of motor control, among other symptoms.
vessels (National Organization for Rare
Brad left his business to start the A-T Children's
Disorders, 2011).

Project, a nonprofit organization aimed at isolating the gene responsible for A-T and The Rare Diseases Act of 2002 established the providing support for affected families. His Office of Rare Diseases (ORD) at NIH to provide efforts were rewarded in 1995, when a scientist information on rare diseases, including their supported by funds from the A-T Children's diagnosis and treatment, and help establish Project identified the gene (called *ATM*) links among investigators, patients, and research associated with the disease (Savitsky et al., subjects. The Office's focus on research soon 1995). It turned out that the *ATM* gene codes prompted a name change to the Office of Rare for a protein that helps mediate a cell's response Diseases Research (ORDR). ORDR staff work to to DNA damage by regulating its progression identify rare diseases where research is lacking through the cell cycle. The isolation of the and to support research in those areas. In 2003, *ATM* gene not only helped researchers better

understand the cause of this rare disease, but it

Institute and ORDR established the Genetic
shed light on a mechanism of cancer.
and Rare Diseases Information Center in 2002.
The next year, the completion of the Human
Research on a rare disease often produces
Genome Project (HGP) opened the floodgates
findings that provide insight into more-common
on a torrent of human genetic data. Once the
diseases. For example, Wilms' tumor (a rare
reference sequence was finished, it became clear
pediatric cancer) research has been cited as
that the human genome contained fewer genes
a model for understanding the genetics and
than originally expected—about 25,000 total.
molecular biology of pediatric cancers in general
After scientists had established the approximate
(Feinberg and Williams, 2003). Research into
number of human genes, they turned their
Tangier disease (a very rare disease associated
attention to assessing the amount of genetic
with improper cholesterol processing) identified
variation among human populations. The aim
a target for therapy to lower the risk for heart
is to associate specific genetic variations with
disease and provided insight into Alzheimer's

diseases, both common and rare. As seen in the
disease (Delude, 2009). In other cases, research
following graph (Figure 2), the pace of disease-
findings have helped prevent a rare disease. For
gene discovery shows no sign of leveling off
example, women can follow simple nutritional
(McKusick-Nathans Institute et al., 2005).
measures to reduce the incidence of birth
defects such as spina bifida in their children.
Soon after scientists began to explore genes
related to disease through the HGP, NIH began
Many of the same patients and families who
researching human genetic variation through
lobbied for the passage of the Orphan Drug Act
the International HapMap Project. Data from
worked to create a nonprofit organization that
the HGP indicated that the genomes of any two
would address their needs. Founded in 1983,
humans are, amazingly, more than 99 percent
the National Organization for Rare Disorders
the same. This observation also means that any
(NORD) provides information about diseases,
two individuals have several million differences
referrals to patient organizations, research grants,
in their genomes.

and advocacy for the rare diseases community.

The most common type of genetic variation is

2.0 The Impact of Genomics on Rare

called a single nucleotide polymorphism (SNP,

Diseases

pronounced “snip”). A SNP is a place in the

Most rare diseases are caused by genetic mutations

genome where individuals may vary by a single

or variations. In fact, we now think that 80 percent

base pair. The human genome contains more

or more of rare diseases have a genetic cause

than 10 million different SNPs (International

(NIH, 2010; NORD, 2007). This means that we

HapMap Consortium, 2007). SNPs that are

can use genetics and rare diseases in a curriculum

clustered close together on the chromosome

supplement to address concepts such as these:

are inherited together as a single unit, or

• Some rare diseases are more prevalent in

haplotype. The International HapMap Project

certain groups.

used DNA samples from people of diverse

• Inherited and environmental factors affect the

ethnic backgrounds to assemble a map of these

function of an organism and may contribute

haplotype blocks.

to the occurrence of rare diseases.

• People affected by inherited rare diseases

The International HapMap Project, completed in

should not be stigmatized.

2005, produced a map containing data on more

• People affected by inherited rare diseases can

than 1.3 million SNPs (International HapMap

lead meaningful lives.

Consortium, 2005). Scientists immediately

used HapMap data to conduct genome-wide

To help provide information on genetics and rare

association studies, in which genomes from

diseases, the National Human Genome Research

many people are rapidly scanned to identify

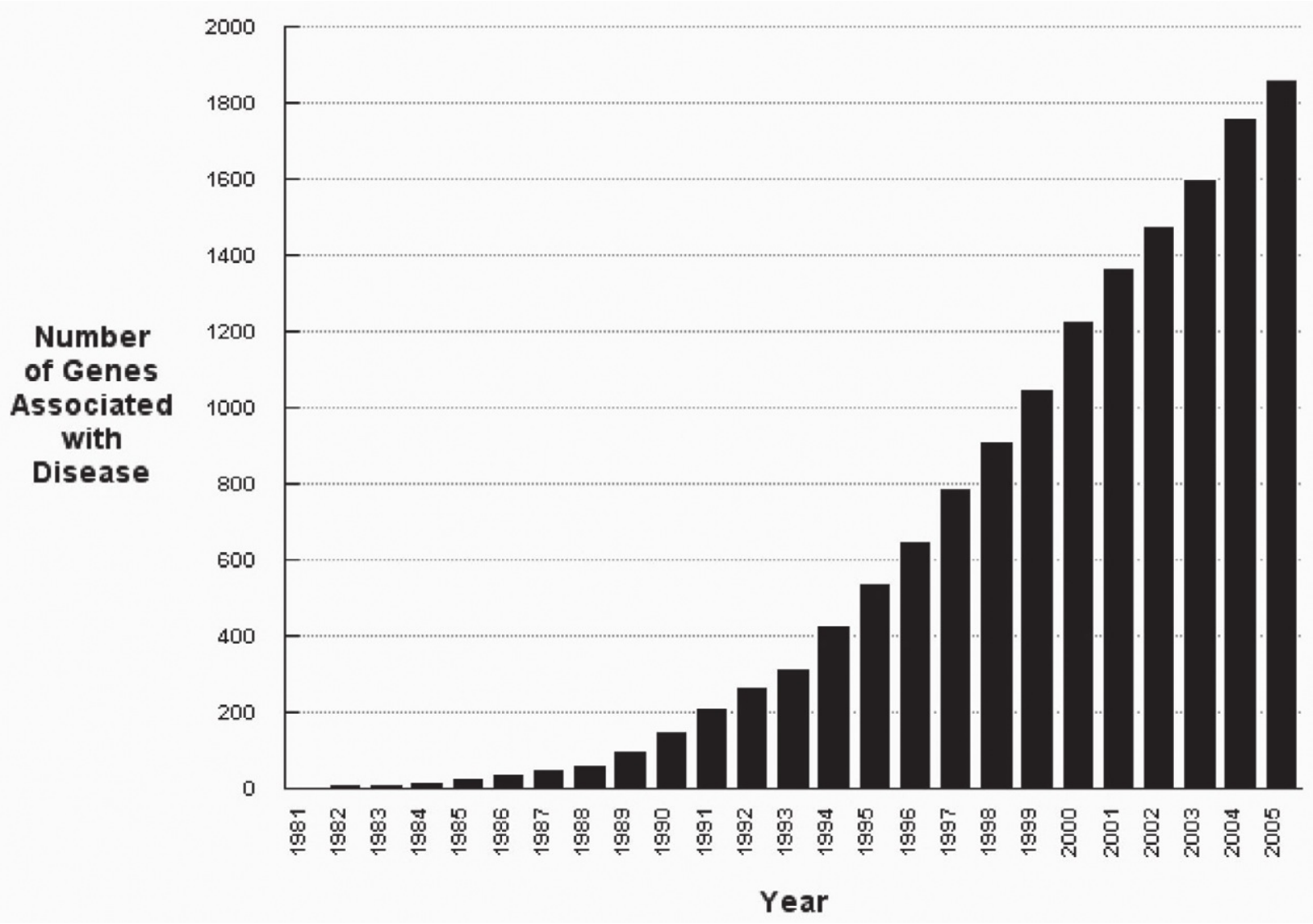


Figure 2. *Cumulative pace of disease-gene discovery in humans, 1981–2005.*

Source: Online Mendelian Inheritance in Man, OMIM. McKusick-Nathans Institute of Genetic Medicine, Johns Hopkins University (Baltimore, MD) and National Center for Biotechnology Information, National Library of Medicine (Bethesda, MD). World Wide Web URL: http://www.ncbi.nlm.nih.gov/omim/)

SNPs associated with diseases. Once the

variations involving thousands of bases of DNA

scientists characterize the disease-associated

sequence are also being investigated. Such

SNPs, they can use the data to help prevent,

structural variations are associated with variation

diagnose, and treat diseases. Within two years,

in gene expression (Stranger et al., 2007), female

HapMap data helped identify more than
infertility (Stefansson et al., 2005), susceptibility
50 genes associated with diseases, including
to HIV infection (Gonzalez et al., 2005), systemic
type 2 diabetes, Crohn's disease, elevated
autoimmunity (Fanciulli et al., 2007), and genetic
cholesterol, rheumatoid arthritis, multiple
disorders such as Williams-Beuren syndrome and
sclerosis, and prostate cancer (Massachusetts
velocardiofacial syndrome (Freeman et al., 2006;
General Hospital, 2007).
Lupski and Stankiewicz, 2005).
The completion of the International HapMap
Some rare diseases are caused by simple genetic
Project did not stop the exploration of human
mutations or variations and can serve as good
genetic variation. In 2007, a second-generation
examples for middle school students learning
human haplotype map was assembled
about a disease and its biological functions
containing data on over 3.1 million SNPs
as well as the fundamentals of genetics. The
(International HapMap Consortium, 2007). This
inheritance of single-gene diseases is relatively
second map, with its increased density of SNPs,

simple. The more-common single-gene
allows researchers to identify recently inherited
disorders include the following:
chromosomal segments that may hold a key to
• sickle cell disease: A recessive disorder in which
understanding rare disease–associated variations
affected people produce abnormal hemoglobin.
that until now have been very difficult to detect.
• cystic fi brosis: A recessive disorder in which
the body produces thick, sticky mucus that
The single base variations associated with the
clogs the lungs and leads to infections. It is
HapMap Project are not the only types of genetic
the most common fatal genetic disease in the
variation associated with disease. Structural
United States.

Information about Rare Diseases and Scientific Inquiry

Figure 3. *Data from the International HapMap*

and to lack the DNA or RNA genome found in

Project are being used to identify genes

viruses. The term prion was coined by Stanley

associated with rare diseases.

Prusiner in 1982 to describe proteinaceous

infectious particles associated with diseases

such as scrapie in sheep, bovine spongiform

encephalopathy (mad cow disease) in cattle, and

Creutzfeldt-Jakob disease in humans.

The infectious nature of prions in humans was

first observed among the Fore people living in the

Source: http://hapmap.ncbi.nlm.nih.gov

highlands of New Guinea in the 1950s. Women

• Tay-Sachs disease: A recessive disorder that

and children were dying from a progressive brain

results in the progressive destruction of the

disease called kuru by the local people. Research

nervous system in children. After genetic

by Carleton Gajdusek established that the

testing and community counseling programs

infectious agent, then thought to be a conventional

became available in 1970, the incidence

virus, was being transmitted through the practice

of Tay-Sachs disease in the United States

of cannibalism (Gajdusek et al., 1967).

and Canada decreased by 90 percent in the

Jewish population most at risk for the disease

All prion diseases characterized so far affect the

(Kaback et al., 1993).

structure of the brain or other neural tissues

• Huntington’s disease: An autosomal dominant

and are untreatable and fatal. The prion particle

disorder that usually appears during middle

is derived from a protein that is a normal part

age and leads to progressive loss of control

of the central nervous system. For reasons

over movement and intellectual faculties.

unknown, the normal protein, PrP, sometimes

misfolds, and in its new conformational state

Today, about 1,500 different tests are available

is able to induce other PrP molecules to do the

to detect mutations associated with genetic

same. This wave of PrP molecules turning into

diseases. This number may seem large, but it

prions becomes an assault on the brain, thus

falls well short of the number of rare diseases

producing the disease symptoms.

thought to have genetic causes (National Center

for Biotechnology Information, 2009). Many

There are many unanswered questions about
of these genetic tests are offered by just a few
prions, including, what’s the role of the PrP
laboratories across the country. Furthermore,
protein in the cell? Two recent studies suggest
the tests may be expensive and may not be
a possibility to explore (Steele et al., 2006;
covered by medical insurance.
Zhang et al., 2006). We know that although
prion diseases exclusively affect the nervous

3.0 Rare Infectious Diseases

system, the PrP protein is found throughout
Some rare diseases are caused by infection with
the body. The two studies show that the PrP
a pathogen. Rare diseases spread by pathogens
protein is expressed on the surface of stem cells
have the potential to become common diseases,
in the bone marrow and on cells that become
provided that conditions promoting transmission
neurons. In both cases, PrP seems to support
are present. The spread of AIDS illustrates how
the ability of the cells to mature and divide.
a once rare disease (because it was new) can
Establishing the normal role for PrP should
become common in a relatively short time.

open new avenues for understanding and, ultimately, treating this rare but devastating class

One class of rare diseases is associated with an of diseases. As research into infectious diseases unusual type of infectious agent called prions, continues, the goal is to make the common which are thought to consist entirely of protein diseases rare and the rare diseases extinct.

4.0 Rare Diseases Caused by

Table 9. Industrial Chemicals and Their Environmental Toxins

Chemical	Disease(s) Associated Diseases
Asbestos	Asbestosis; mesothelioma
Beryllium	Chronic beryllium disease

Some rare diseases result not from faulty genes or infection by pathogens, but from exposure to toxins or other extrinsic factors in the environment. As with infectious diseases, those caused by exposure to environmental toxins

may be either common or rare, and the rare

Coal dust

Pneumoconiosis

ones have the potential to become common.

Cotton dust

Byssinosis

Dioxins,

Chloracne

Harmful extrinsic factors may be of natural or

polychlorinated

human origin. Natural factors include ionizing

biphenyls (PCBs)

radiation (from sunlight or elements such as

Nylon flocking

Flock worker’s lung

radon), heavy metals (such as lead and mercury),

and chemicals produced by organisms. Many

Silica

Silicosis

plants produce chemicals that function as

Vinyl chloride

Angiosarcoma

pesticides. Other plant toxins are produced in

Welding fumes

Metal fume fever

response to stresses caused by severe weather,

Source: Adapted from G.M. Solomon. 2005. Rare and

ultraviolet light, and infection by microbes.

common diseases in environmental health. San Francisco

Medical Society Web site. Retrieved August 10, 2008: http://

Some of the most potent naturally occurring toxins

www.sfms.org/AM/Template.cfm?Section=Home&template=/

are produced by microorganisms. Botulinim,

CM/HTMLDisplay.cfm&ContentID=1644.

for example, is produced by the bacterium

Clostridium botulinum and causes the rare disease

the diseases are, in fact, multifactorial, meaning

botulism. Most cases of botulism involve eating

that they result from interactions between

food contaminated with preformed botulinum

genetic and environmental factors. Since the

neurotoxin. In rare cases, called colonization

HGP was completed in 2003, researchers have

botulism, a person eats food containing spores

been working to establish the genes' functions

of *C. botulinum*. The spores germinate inside the

and relationships to both health and disease.

body, resulting in a colony of bacteria that then

produce the toxin. The appearance of colonization

Some scientists are exploring how the

botulism is associated with certain risk factors,
interaction of genes and environmental
most commonly the digestive disorder Crohn’s
factors produces disease. For example,
disease (Health Canada, 2007).
Michael Borchers has been investigating a
receptor protein called NKG2D found on the
Other rare diseases are caused by exposure to
surface of lung cells (Borchers et al., 2006).
industrial chemicals. This can happen as a result
Normally, the NKG2D protein helps the
of lifestyle choices (such as smoking) or living
immune system attack and destroy lung tissue
or working in a harmful environment. Some
damage caused by infection from a pathogen.
industrial chemicals are strongly associated with
However, when the lungs experience chronic
specific diseases. For example, virtually all cases
low-level damage from environmental
of mesothelioma are attributed to exposure to
toxins through smoking or exposure in the
asbestos. Table 9 lists several harmful industrial
workplace, the amount of tissue damage may

chemicals and the diseases that result from

exceed the body’s ability to repair it. In such

exposure to them.

cases, the activity of NKG2D is unwanted

because it stimulates the immune system to

Although the causes of rare diseases can be

attack the affected tissue—and contributes

classified as genetic or environmental, many of

to chronic lung disease instead providing

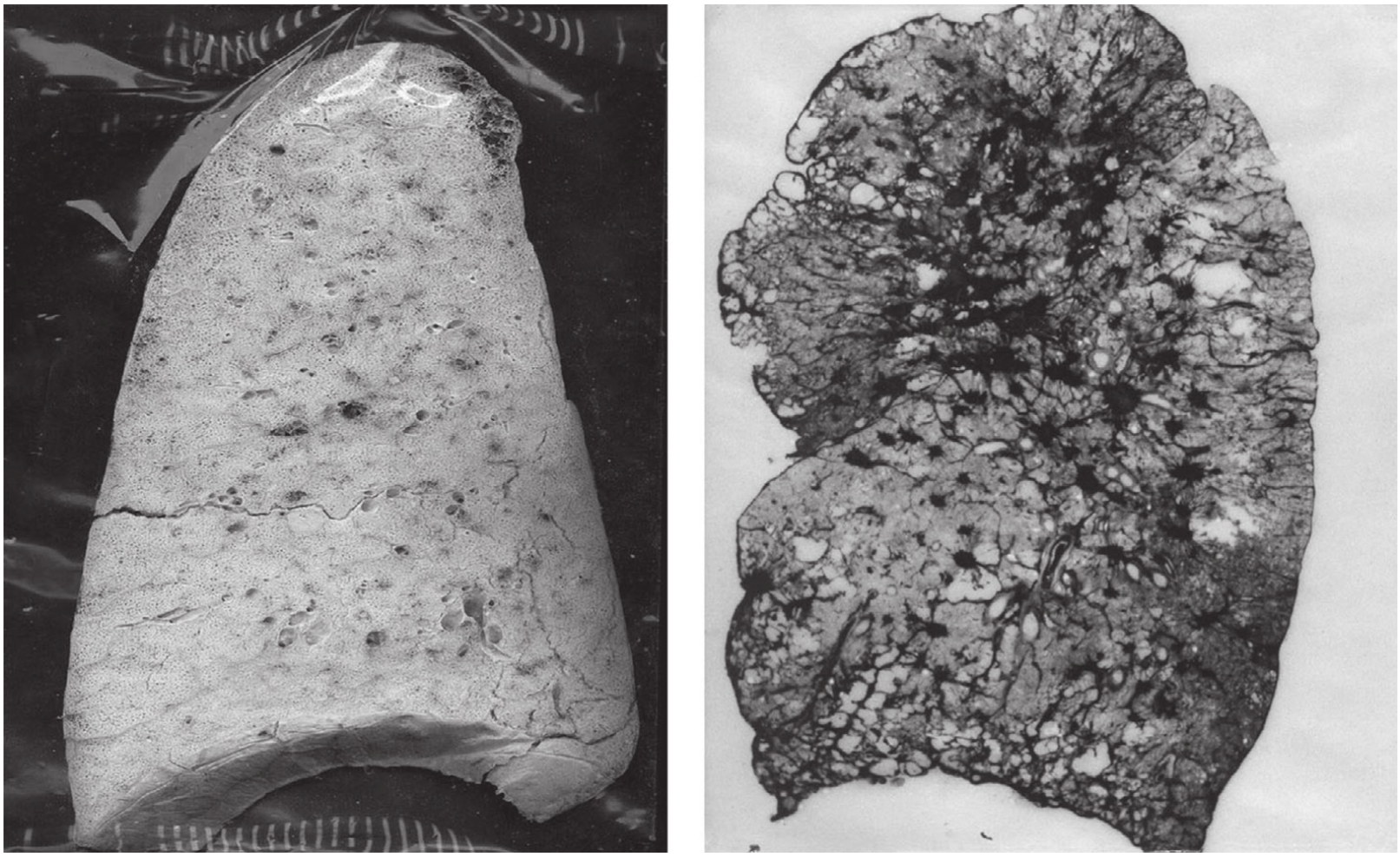


Figure 4. *Long-term exposure to coal dust causes the illness known as black lung. Normal lung (left) and affected lung (right).*

Source: www.cdc.gov/niosh, National Institute for Occupational Safety and Health (NIOSH), Division of Respiratory Disease Studies

protection from it. Borchers believes that by

Streptococcus bacteria strains. This is the same

blocking the activity of NKG2D, he can stop

kind of bacteria responsible for causing strep

this immune response and minimize damage

throat. Most strep strains are easily killed by

to the lungs (University of Cincinnati, 2006).

antibiotics. Some are not, though, and, under

the right set of conditions, can cause NF. These

Other causes of rare diseases include

conditions include the following:

• nutritional defi ciency: for example, beriberi

• An opening in the skin through which the

results from a lack of thiamine;

bacteria enter the body. The opening can be

• injury: for example, commotion cordis

large, as a result of trauma or surgery, or very

is associated with ventricular fi brillation

small, as from a pinprick or paper cut.

and sudden death, which result from a

• Contact with the bacteria, either from inside

nonpenetrating blow to the chest; and

the person or from another infected person.

• a treatment for another disease: for example,

• Infection by an invasive strain of the Group
radiation is often used as a cancer treatment,
A *Streptococcus* bacteria.
but it may also cause radiation-induced
meningioma (a rare central nervous system
After the bacteria enter the body, they reproduce
tumor).
quickly and release toxins and enzymes that
destroy soft tissue and fascia. The dead tissue
must be removed to save the patient’s life.

5.0 Rare Diseases Featured in This

The bacteria are able to elude the body’s

Curriculum Supplement

immune system and spread through different

5.1 Necrotizing Fasciitis

tissue layers. In addition to the tissue damage,
Necrotizing fasciitis (NF) is a bacterial
the infection can result in toxic shock, which
infection. The bacteria attack the soft tissue and
is characterized by a drop in blood pressure;
the fascia, a sheath of tissue that covers muscles.
a weak, rapid pulse; fever; dizziness and
Most commonly, the infection is from Group A
confusion; and difficulty breathing.

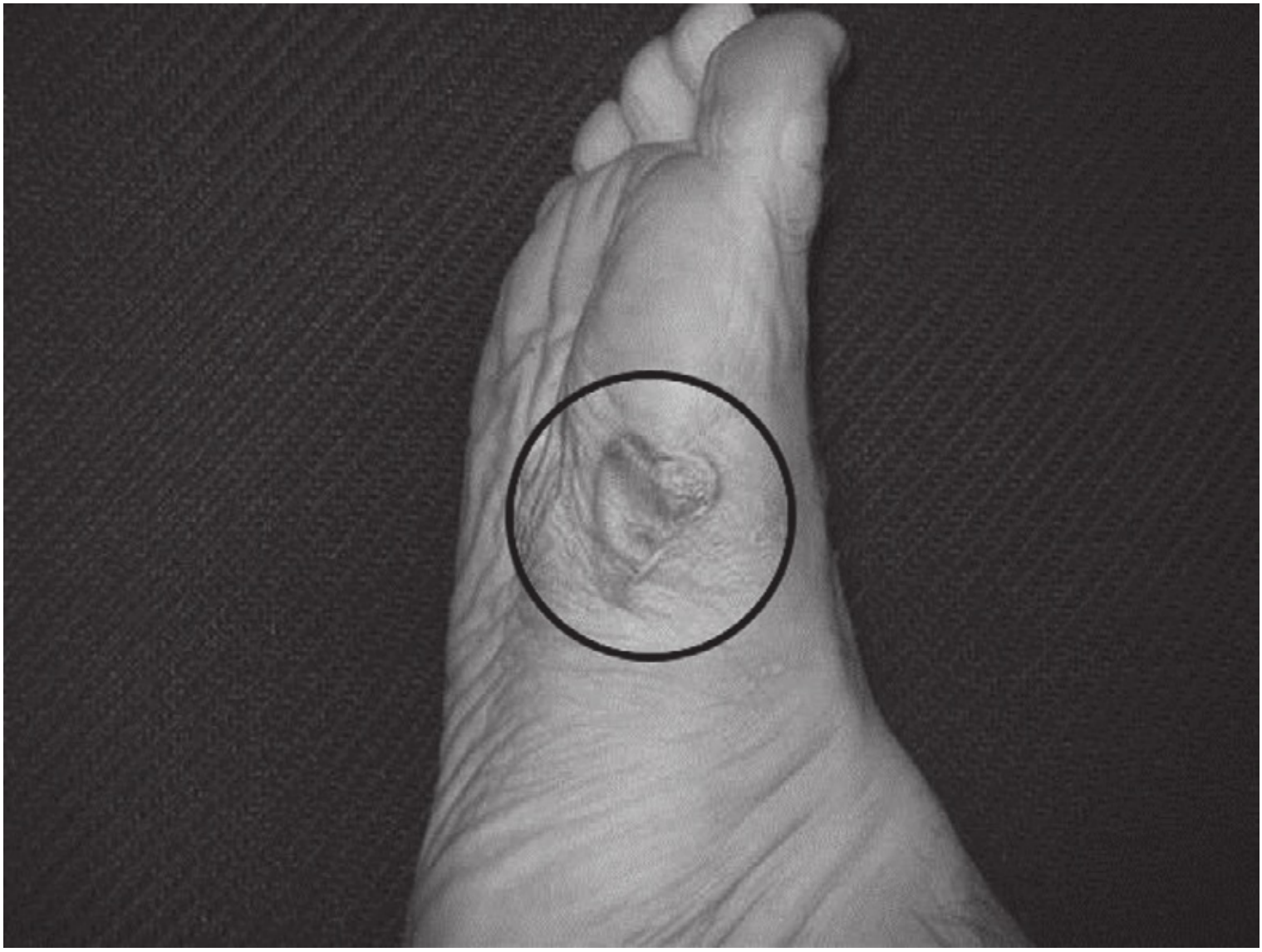


Figure 5. *An invasive strain of the Group A Streptococcus bacteria can enter the body through a foot blister.*

Fortunately, NF is rare, although accurate statistics are hard to find. In 1996, the CDC estimated that there were between 500 and 1,500 cases of NF in the United States and that 20 percent of these resulted in death (National Necrotizing Fasciitis Foundation (NNFF), 2009).

Symptoms of NF: NF produces flu-like

symptoms, so people initially believe that they simply have the flu. Misdiagnosis is common, which can have devastating consequences because the bacterial infection advances so fast. The symptoms of NF progress as follows (NNFF, 2009):

Early symptoms (usually within the first

Source: NTECH HEALTH AND WELLNESS

24 hours)

• An opening in the skin (from even a slight

Treatment of NF: NF requires treatment at

trauma) has appeared, allowing the bacteria

a hospital. The patient is given intravenous

to enter the body.

antibiotics, and the infected tissue is removed.

• The patient feels discomfort in the general

Depending on the severity of symptoms, other

area of the trauma.

treatments may be needed, such as blood

• The pain increases out of proportion to

transfusions and medications to raise blood

the injury.

pressure and boost the immune system.

• Flu-like symptoms appear such as vomiting,

diarrhea, dehydration, fatigue, weakness,

Surviving NF: Patients surviving NF may be

muscle pain, and fever.

left with minimal to severe scarring. Almost

• Intense thirst develops as the body

all patients need to have at least some skin

dehydrates.

removed. As a result, they may have to undergo

a series of skin grafts. In some cases, amputation

Advanced symptoms (usually within three to

of an affected limb is necessary.

four days)

• The painful area of the body begins to swell

5.2 Marfan Syndrome

and may show a purplish rash.

Marfan syndrome is a genetic disease of the

• The painful area may develop large, dark

connective tissue. It’s caused by mutations in the

blisters.

gene that codes for the connective tissue protein

• The wound may take on a bluish, white, or

fibrillin-1. As a result of the mutated *fibrillin-1*

dark, mottled, fl aky appearance.

gene, another protein called “transforming

growth factor beta” (TGFß) increases in

Critical symptoms (usually within four

concentration, causing certain connective tissue

to five days)

problems. The Marfan syndrome phenotype is

• Blood pressure drops severely.

inherited as an autosomal dominant trait. This

• Heartbeat increases.

means that a single copy of the mutated gene

• A rash may appear over the body, caused by

is enough to cause the disorder. It also means

toxins released by the bacteria.

that an affected person has a 50 percent chance

• Toxic shock causes the body’s organs to

of passing on the disorder to each child. The

shut down.

syndrome is mostly an inherited condition,

• Unconsciousness results as the body becomes

but in about 25 percent of cases, it’s caused

too weak to fi ght the infection.

by a spontaneous mutation in a sperm or egg

cell of an unaffected parent (Dietz, 2009). The

management, it’s possible for people with

National Marfan Foundation estimates that

Marfan syndrome to live a normal life span.

about 200,000 people in the United States are living with Marfan syndrome or a related

Diagnosis of Marfan Syndrome: The connective tissue disorder (National Marfan connective tissue problems associated with Foundation, 2011).

Marfan syndrome can affect multiple body systems. This can complicate diagnosis of the

Features of Marfan Syndrome: People with disorder. Doctors may treat patients with the Marfan syndrome have the genetic mutation syndrome for several medical problems at once in all their cells. This means that the disorder without realizing that they stem from a single affects the connective tissue in many different cause. Although we know that Marfan syndrome body systems. The medical features associated is caused by mutations in the *fibrillin-1* gene on with Marfan syndrome appear at all ages, chromosome 15, there's no simple blood test including in infants and small children. Some that can diagnose the disorder. Instead, doctors of the most common features of Marfan have established a set of diagnostic criteria to syndrome are listed below (Table 10). With

use. These criteria span various body systems

early diagnosis, proper treatment, and careful

and are classified as either major or minor.

Table 10. Features of Marfan Syndrome

Cardiovascular System

The **aorta** (main blood vessel that carries blood from the heart) may be enlarged and weakened.

The layers of the aorta may be separated, causing it to tear more easily.

The mitral valve that separates the upper and lower halves of the left side of the heart may be enlarged and may not work properly.

Skeletal System

Tall and thin body type

Scoliosis (curvature of the spine)

Chest sinks in or sticks out

Flexible joints

Flat feet

Teeth very crowded together

Ocular System

Severe **myopia** (nearsightedness)

Dislocated eye lens

Detached retina

Early glaucoma or cataracts

Other Body Systems

Stretch marks on skin, not from pregnancy or weight gain

Sudden lung collapse

Swelling of the sac that surrounds the spinal column

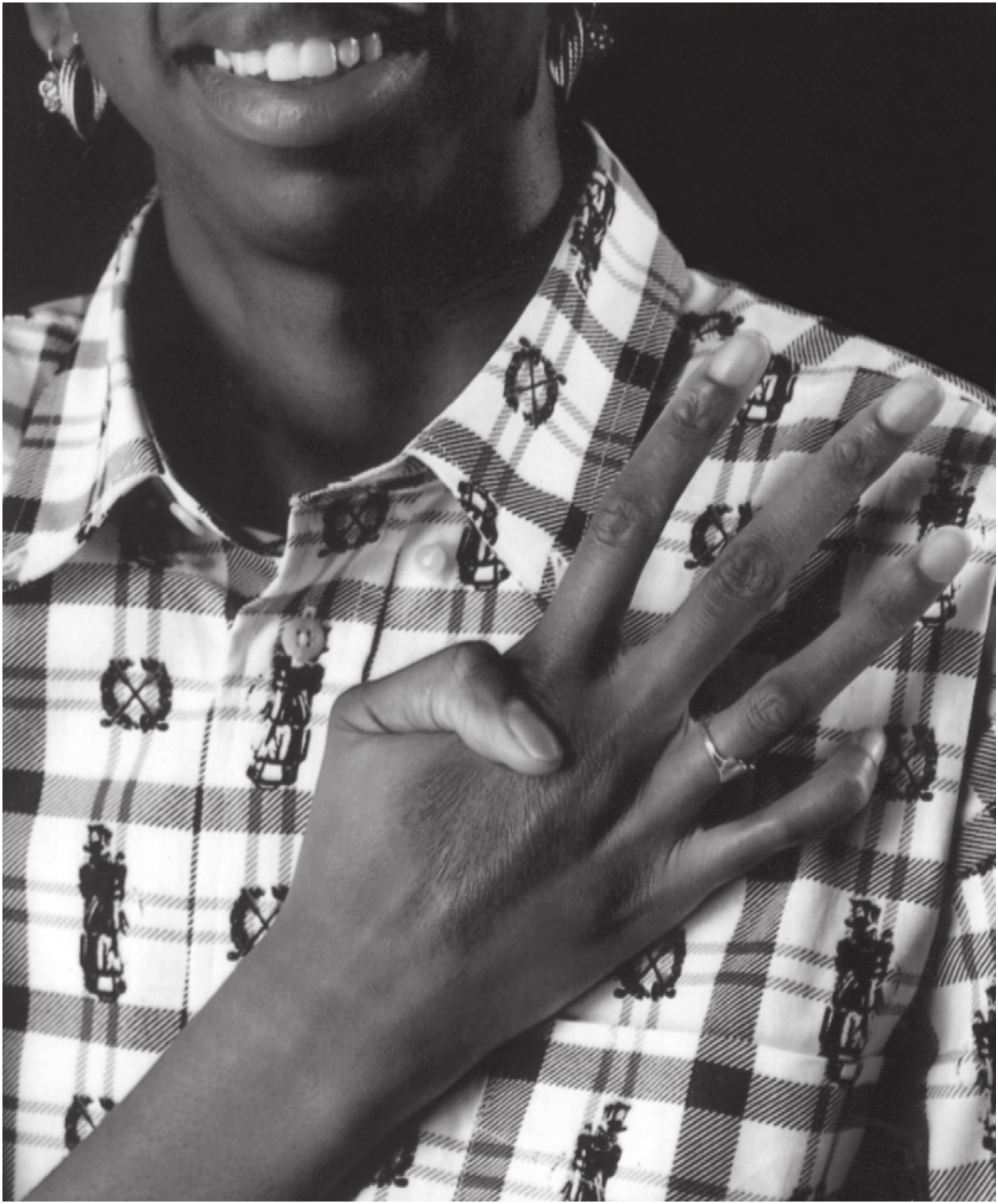


Figure 6. *Marfan syndrome is associated with*

program. Table 11 lists some of the available

fl exible joints.

disease-management options.

5.3 Childhood Leukemia

Leukemias are cancers of the blood or bone marrow that usually result in the overproduction of white blood cells and that are classified by how long it takes for the disease to appear and worsen (acute and chronic) and by the type of blood cell affected (lymphocytic or myeloid):

• Acute leukemia is characterized by the rapid appearance of immature blood cells, called blasts, produced in the bone marrow. This overcrowding of cells prevents the bone marrow from making healthy blood cells. The lack of healthy white blood cells (which help fi ght infection) leaves the patient vulnerable to repeated bouts of colds and fl u. The lack of healthy red blood cells leads to anemia and fatigue. Acute forms of leukemia may occur in people of all ages, but they are often the forms seen in children.

Source: National Marfan Foundation

• Chronic leukemia is characterized by a more

gradual accumulation of relatively mature
blood cells. It may take months or years to
To make a diagnosis of Marfan syndrome, the
progress. This form of leukemia can also
doctor compares the patient’s medical history,
be found in people of all ages but is more
results of a physical examination, and results
common among older people.
from laboratory tests with the set of diagnostic
• Lymphocytic leukemia is a cancer of the B
criteria. If no one in the patient’s family has
cells, a kind of lymphocyte (or white blood
Marfan syndrome, the doctor makes the
cell) that plays a role in the immune system.
diagnosis if the patient has major criteria in two
• Myeloid leukemia is a cancer of other cells,
different body systems and minor criteria in a
such as red blood cells, platelets, and other
third body system. If the patient has a parent or
types of white blood cells.
sibling with Marfan syndrome, the doctor makes
the diagnosis if the patient has major criteria in
This supplement is concerned with acute
one body system and minor criteria in a second
lymphoblastic leukemia (ALL), which is the

body system. A person may have many features
most common form of leukemia in children.
associated with Marfan syndrome in a single
The Leukemia and Lymphoma Society estimates
body system but still not be diagnosed with the
that in 2009, there were 5,760 new cases of ALL
disorder.
in children in the United States.
Treatment of Marfan Syndrome: Although
Symptoms of ALL: The most common
there’s no cure for Marfan syndrome, certain
symptoms appearing in children with ALL
treatments can minimize or, in some cases,
are fever; recurring infections; easy bruising
prevent complications. Depending on which
or bleeding; lumps in the neck, underarms,
body systems are affected, an appropriate team
stomach, or groin; pain or a feeling of fullness
of specialists create an individualized treatment
below the ribs; fatigue; and the loss of appetite.
Information about Rare Diseases and Scientific Inquiry

Table 11. Disease-Management Options
chromosomes may be seen in the leukemia cells
for Marfan Syndrome

but not in unaffected cells taken from other

parts of the body.

Cardiovascular System

• **Echocardiogram**s to assess the size of the

Treatment of ALL: The treatment of ALL has

aorta

made continual progress since the 1960s, mostly

• Medications to relieve stress on the aorta

thanks to the results of clinical trials on children

• Corrective surgery

with the disease. During clinical trials, one

Skeletal System

group of children receives the so-called standard

• Annual examinations to look for changes in

treatment, which is the best care known at the

the spine and breastbone

time. Researchers compare the health of this

• Orthopedic braces

group of children with one or more additional

• Corrective surgery

groups of children who receive a modified form

Ocular System

of the standard care that is designed to test some

• Early, regular eye exams

new treatment, such as a different dose or a new

• Eyeglasses or contact lenses

drug. The success of a treatment is described in

• Corrective surgery

terms of its five-year survival rate, which refers

to the percentage of patients who live at least

Nervous System

five years after cancer was diagnosed. Today, the

• Medication for pain

five-year survival rate for children with ALL in

Pulmonary System

the United States is over 80 percent (American

• Avoidance of smoking

Cancer Society, 2009).

• Examination to detect breathing problems

during sleep

Current treatment for ALL consists of several

• Medical attention for collapsed lung

phases:

Physical Activity

• *Induction Chemotherapy*: This initial phase

• Avoidance of collision and contact sports

uses a combination of drugs such as

• Individualized exercise plan

prednisone and **vincristine** to kill most of

the cancer cells.

• *Consolidation Therapy*: In this phase, a different combination of drugs is used to target any remaining cancer cells.

• *Preventive Therapy*: The aim of this phase is to prevent the spread of the disease to the central nervous system. It may involve irradiation of the head and the injection of drugs directly into the spine.

• *Maintenance Therapy*: In this final phase of treatment, lower doses of the drugs are administered for up to three years in an attempt to keep the disease from reappearing.

Diagnosis of ALL: In addition to a physical exam and patient history, blood tests are used to diagnose ALL. The different types of blood cells are counted to determine whether they are present in abnormal ratios. A **biopsy** of the bone marrow allows cells from the bone, blood, and bone marrow to be examined for an abnormal appearance. A cytogenetic analysis also may be carried out, because some forms of ALL are associated with the appearance of trisomies (having three instead of the normal two copies of a chromosome) in the affected cells. Trisomies can be detected in a kind

Some high-risk ALL patients may also receive a bone marrow transplant.

Causes of ALL: ALL has no single cause. Ultimately, ALL is a genetic disease in the sense that it results from genetic damage (mutation)

karyotype. To make the karyotype easier to analyze, the individual chromosomes are cut out of photograph of the chromosomes called a from the original photograph and rearranged in pairs. A trisomy involving one or more

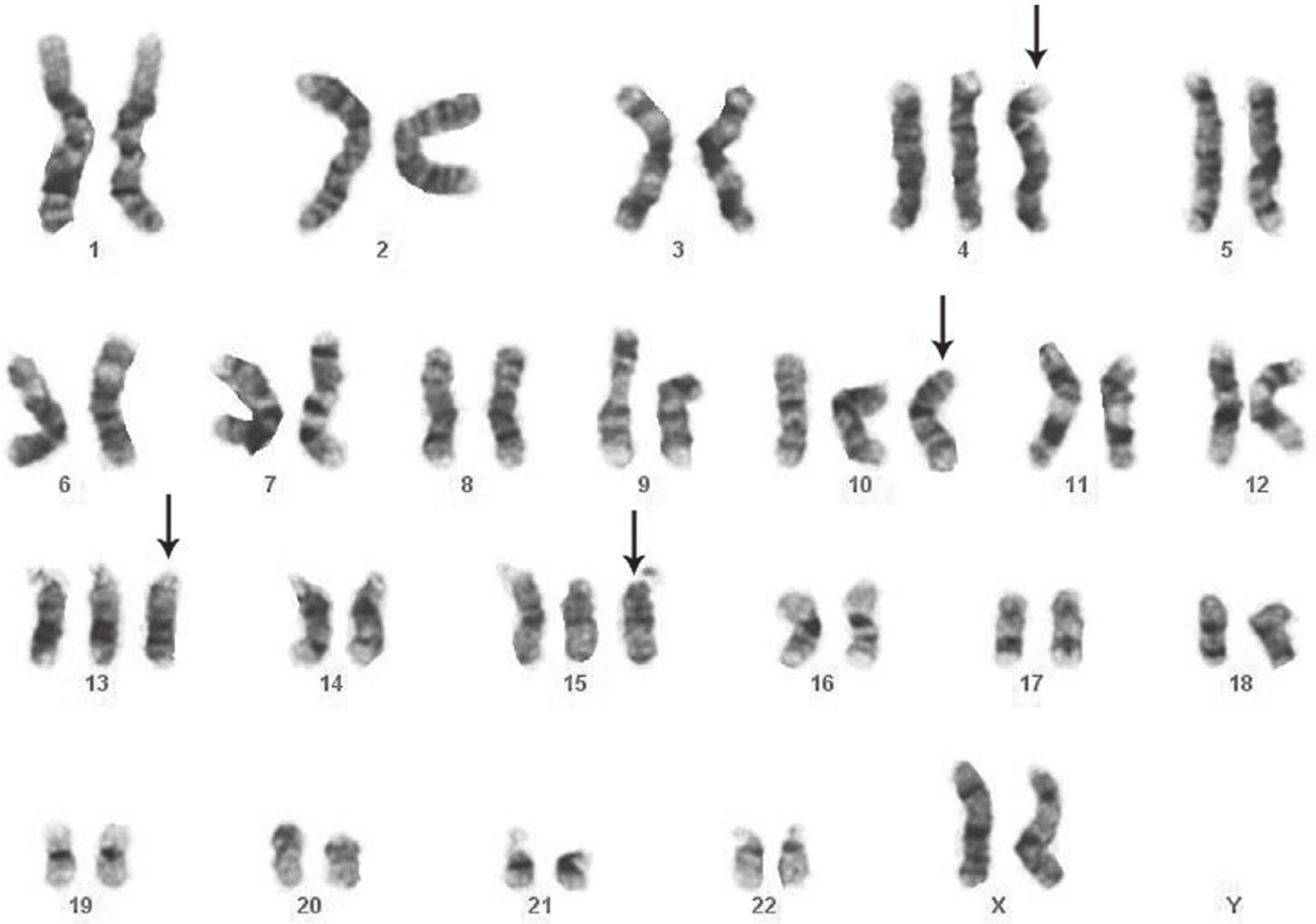


Figure 7. *A karyotype from a leukemia patient may show abnormal numbers of chromosomes.*

Source: Genetics Department, Affi liated Laboratories, Inc., Bangor, Maine to a single cell that then spreads to progeny

them appropriate for study by middle school

cells. The DNA damage may result from natural

students who have only basic knowledge of the

or medical radiation (that is, from the sun

relationship between genotype and phenotype.

or medical X-rays) or from environmental

In addition, single-gene disorders allow for the

exposure to toxic substances such the solvent

study of the fundamentals of inheritance.

benzene. ALL is sometimes linked to infection, as from the human T-lymphotropic virus. Most cases of ALL are spontaneous, meaning that the mutations occurred spontaneously in that individual patient and were not inherited. ALL can, however, sometimes run in families.

6.0 Rare Diseases as a Topic for the Middle School Science Classroom

The topic of rare diseases provides an excellent context for teaching core life science content in the middle school classroom (see Tables 3 and 4). According to the *National Science Education Standards* (*NSES*), middle school Middle school students are often introduced to the concept of disease as the breakdown of structures or functions of an organism. Rare diseases offer opportunities to expand on that concept by exploring how diseases are linked, not just to genetics, but also to the environment and infection by pathogens. Infectious diseases are an important example of an interrelationship between organisms, since we can use them to illustrate structural similarities and differences between the cells of the host and the pathogen. Furthermore, students can examine the

structure-function relationship of systems in
students should develop a basic understanding
the body by studying the differences between
of heredity and genetics (NRC, 1996). Since the
diseased and unaffected states.
majority of rare diseases have a genetic basis,
we can use them as real-life examples of the
Rare diseases offer an engaging context for
relationship between genes and health. Many
exploring body systems, which are often treated
rare diseases are linked to single genes, making
as a vocabulary-laden series of diagrams.
Information about Rare Diseases and Scientific Inquiry

Figure 8. *Some rare diseases have been extensively studied, while others have not.*

Investigating how a rare disease affects a body system can help students understand how that system normally works. The wide variety of rare diseases ensures that we can select examples that focus primarily on individual body systems. We can use other rare diseases to illustrate functional interactions between body systems. Furthermore, this curriculum supplement gives students a chance to address any misconceptions

they may have about rare diseases. Most students know very little about rare diseases. They usually haven't experienced one themselves or in their immediate family. This lack of familiarity can promote misconceptions about rare diseases and the healthcare system's responses to them.

Source: PhotoDisc

An informal survey of Web sites for support groups for patients with rare diseases suggests increased funds from the U.S. government several misconceptions that the curriculum have been available to study rare diseases. supplement should address, including the

• *Family Doctors Are Well Equipped to Diagnose* following:

Rare Diseases: Despite technologies such as

• *All Rare Diseases Are Being Actively* the Internet that make information about

Researched: Many people, especially those rare diseases available at a moment's notice, with health insurance and good health, most family doctors are ill equipped to may not be aware of the limitations of diagnose a rare disease. In many instances, the healthcare system in terms of the

a patient with a rare disease will be the
resources available to treat patients and
fi rst one ever encountered by the doctor.
the state of medical knowledge available
Furthermore, many rare diseases share
to develop drugs and treatments for
symptoms with more-common diseases, and
rare diseases. Despite the efforts of the
doctors naturally think of common diseases
government, pharmaceutical companies, and
fi rst when considering the diagnosis. This
patient support organizations, many rare
knowledge may help students understand
diseases are underfunded and not actively
why many patients with rare diseases will
researched.
visit a number of different doctors over a
• *A Disease Must Not Be Rare If It Is Well*
one-to-fi ve-year period before obtaining a
Known: Students often assume that if they
correct diagnosis.
have heard of a disease, it must not be
• *Rare Diseases Are Fatal*: Since, by defi nition,
rare. Examples of well-known rare diseases
most people have not encountered rare

are cystic fi brosis, sickle cell anemia, and
diseases fi rsthand, their impressions about
mumps. By addressing this misconception,
these diseases come from print and television
this curriculum supplement can help
media. Stories about patients with rare
students understand the statistical defi nition
diseases tend to emphasize children and
of rare diseases.
gravely ill people. Rare diseases display the
• *Very Little Is Known about Rare Diseases*:
same variations as more-common diseases.
Although limited research has been done
Some rare diseases are, in fact, fatal and strike
on some rare diseases, others have been
their victims during childhood. Others are
researched extensively. Especially after the
less serious and can be cured or effectively
passage of the Orphan Drug Act in 1983,
managed.

7.0 Scientifi c Inquiry

Figure 9. *In the classroom, scientifi c inquiry can be both a learning goal and a teaching method.*

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

—NRC, 1996

7.1 Scientifi c Inquiry as a Topic for the Middle School Science Classroom

Scientific inquiry is a topic well suited to the middle school classroom. The *NSES* stress both

Source: Corbis

abilities and understandings about inquiry (NRC, 1996; see Section 7.2 in *Inquiry in the* teaching method (NRC, 1996). To that end, the National Science Education Standards (NRC, content standards for scientific inquiry include 2000)). As discussed in the *NSES*, students are both abilities and understandings about inquiry.

naturally curious about the world. Inquiry-

The *NSES* identify five essential elements of

based instruction offers an opportunity to inquiry teaching and learning that apply across

• engage student interest in and knowledge

all grade levels:

about scientifi c investigation,

1. Learners are engaged by scientifi cally

• sharpen critical-thinking skills,

oriented questions.

• distinguish science from nonscience,

Strategies to improve students' ability to

• make students aware of the importance of

ask scientifi c questions include providing

basic research, and

examples and modeling the formation of

• humanize the image of scientists.

testable questions (Krajcik et al., 1998),

providing materials that stimulate questions

7.2 Scientifi c Inquiry in the **National**

(Chin and Brown, 2002; Harlen, 2001), and

Science Education Standards

encouraging students to formulate their own

Inquiry is a multifaceted activity that

questions (Harlen, 2001).

involves making observations; posing

2. Learners give priority to evidence, which

questions; examining books and other

allows them to develop and evaluate

sources of information to see what is

explanations that address scientifi cally

already known; planning investigations;

oriented questions.

reviewing what is already known in light of

Scientists obtain evidence in the form of

experimental evidence; using tools to gather,

scientifi c data by recording observations

analyze, and interpret data; proposing
and making measurements. They can check
answers, explanations, and predictions; and
the accuracy of the data by repeating the
communicating the results. Inquiry requires
observations or making new measurements.
identification of assumptions, use of critical
In the classroom, students use such data
and logical thinking, and consideration of
to construct explanations for scientifi c
alternative explanations.
phenomena. Unfortunately, students have
—NRC, 1996
diffi culty both using appropriate evidence
(Sandoval and Reiser, 1997) and including it
The *National Science Education Standards*
in their written explanations (Bell and Linn,
recognize inquiry as both a learning goal and a
2000).
Information about Rare Diseases and Scientific Inquiry

3. Learners formulate explanations from
They should also compare their results with
evidence to address scientifically oriented
current scientific knowledge.

questions.

5. Learners communicate and justify their

Scientific explanations are consistent with

proposed explanations.

the available evidence and are subject

Scientists communicate their results in such

to criticism and revision. Furthermore,

detail that other scientists can reproduce

scientific explanations extend beyond current

their work. This gives science an important

knowledge and propose new understandings

quality-control mechanism. Other scientists

that extend the knowledge base. The same is

can use the results to investigate new but

true for students who generate new ideas by

related questions. Students also benefit by

building on their personal knowledge base.

sharing their results with their classmates.

Explanations are rarely a part of classroom

This gives them a chance to ask questions,

practice, and students need to be explicitly

examine evidence, identify faulty reasoning,

taught how to formulate scientific explanations

consider whether conclusions go beyond the

(Kuhn et al., 2006; McNeill and Krajcik, 2007).

data, and suggest alternative explanations.

4. Learners evaluate their explanations in light

of alternative explanations, particularly those

The following chart (Table 12) lists the abilities

reflecting scientific understanding.

and understandings about inquiry appropriate

Scientific inquiry differs from other forms

for middle school, taken from the *NSES*

of inquiry in that proposed explanations

content standards for scientific inquiry (NRC,

may be revised or thrown out altogether

1996). These abilities and understandings

in light of new information. As students

are consistent with student performance

compare their results with those of others,

expectations in the National Assessment of

they may consider alternative explanations.

Educational Progress (NCES, 2011).

Table 12. *NSES* Content Standards for Scientific Inquiry, Grades 5–8

Fundamental Abilities Necessary to Do Scientific Inquiry

• Identify questions that can be answered through scientific investigations.

• Design and conduct a scientific investigation.

• Use appropriate tools and techniques to gather, analyze, and interpret data.

• Develop descriptions, explanations, predictions, and models using evidence.

• Think critically and logically to make the relationships between evidence and explanations.

• Recognize and analyze alternative explanations and predictions.

• Communicate scientific procedures and explanations.

• Use mathematics in all aspects of scientific inquiry.

Fundamental Understandings about Scientific Inquiry

• Different kinds of questions suggest different kinds of scientific investigations.

• Current scientific knowledge and understanding guide scientific investigations.

• Mathematics is important in all aspects of scientific inquiry.

• Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

• Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.

• Science advances through legitimate skepticism.

• 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.

Glossary

antibiotic: A drug that can kill or inhibit the growth of bacteria. Antibiotics are not effective against viruses.

aorta: The largest artery in the human body. It originates in the left ventricle of the heart and extends down into the abdomen.

asthma: A chronic inflammatory disease of the airways. Its symptoms include wheezing, coughing, and shortness of breath.

biopsy: A medical procedure that involves removing of a small amount of tissue for examination.

The tissue sample is often analyzed by a pathologist to determine the presence or extent of a disease.

bone marrow: Spongy tissue found in the hollow interiors of some large bones. Bone marrow contains stem cells that produce various types of blood cells.

cardiologist: A doctor with specialized training in the prevention, diagnosis, and treatment of diseases

associated with the heart and circulatory system.

central nervous system: That part of the nervous system consisting of the brain and spinal cord.

chromosome: An organized package of DNA found in the nucleus of the cell. Humans have 23 pairs of chromosomes—22 pairs of numbered chromosomes, called autosomes, and one pair of sex chromosomes, X and Y.

clinical trial: A controlled study designed to measure the safety or effectiveness of a new drug or medical procedure.

common disease: A disease that affects a relatively large population. In contrast, a rare disease is defined as one affecting fewer than 200,000 people in the United States.

conjunctivitis: An inflammation of the outermost layer of the eye (also called pinkeye).

The inflammation may be caused by a virus, a bacterium, or an allergic reaction.

connective tissue: A type of tissue that functions to connect other tissues to each other and hold organs in place. The protein collagen is an important structural component of connective tissues.

disease: A condition characterized by the improper functioning of one or more body parts or systems.

The most common causes of diseases are genetic mutation, infection by a pathogen, and exposure to a harmful substance in the environment.

echocardiogram: A medical procedure that uses sound waves to create a moving picture of the heart.

An echocardiogram provides a more detailed view of the heart than an X-ray does, and it doesn’t involve exposure to radiation.

Ehlers-Danlos syndrome: A group of inherited diseases of the connective tissue. The syndrome is caused by defects in the collagen protein that result in a variety of symptoms affecting multiple body systems. The condition may be mild or life threatening.

genetics: The study of the inheritance patterns of traits. Genetic information is coded in the molecule DNA. Changes to DNA, called mutations, can cause disease.

heart murmur: An extra or unusual sound in the heartbeat. Some heart murmurs are harmless, while others indicate heart problems.

infectious agent: Usually a microscopic agent, such as a virus or bacterium, that can cause an infection and be spread from person to person.

institutional review board: A committee established to approve, monitor, and review medical research involving human subjects.

karyotype: A photograph showing the number and shape of an individual's chromosomes.

leukemia: A cancer of the blood-forming tissues in the bone marrow. Leukemia is often characterized by the production of large numbers of unhealthy white blood cells.

lumbar puncture: A medical procedure also known as a spinal tap. It involves obtaining a small sample of cerebrospinal fluid for analysis. It can be used to look for the presence of an infectious disease such as meningitis or for cancer cells.

Lyme disease: A disease transmitted by a tick bite. Caused by a bacterial infection, Lyme disease is characterized by headaches, fever, depression, and a circular skin rash.

lymph node: A small, spherical organ of the immune system. Lymph nodes are distributed throughout the body and are connected by lymph vessels. They trap bacteria and foreign particles.

Marfan syndrome: A genetic disorder of the connective tissue. Because connective tissue is found throughout the body, features of Marfan syndrome are observed in many different body systems.

medical geneticist: A doctor with specialized training in the diagnosis and treatment of genetic diseases.

methotrexate: A drug used to treat various forms of cancer as well as other diseases. It works against rapidly dividing cells by interfering with the synthesis of DNA, RNA, and protein molecules.

mitral valve prolapse: A heart problem resulting from a faulty valve that separates the upper and lower chambers of the left side of the heart. Symptoms of the condition include chest pain, fatigue, heart palpitations, cough, and shortness of breath after activity.

mutation: A change to the sequence of a DNA molecule. Mutations may be caused by radiation, chemicals, viruses, and mistakes that occur during DNA replication.

myopia: A condition in which the eye focuses incorrectly, making distant objects appear blurred (also called nearsightedness).

necrotizing fasciitis: A rare but very serious bacterial infection that can destroy skin, muscle, and underlying tissues (also called flesh-eating disease). If not treated immediately, it can be fatal.

ophthalmologist: A doctor with specialized training in the diagnosis and treatment of eye problems.

Orphan Drug Act: A piece of federal legislation passed in 1983. It gives pharmaceutical and healthcare companies financial incentives to develop drugs and other products aimed at the treatment of rare diseases.

orthopedist: A doctor with specialized surgical training in the treatment of disorders of the skeletal system.

osteogenesis imperfecta: A genetic disease characterized by brittle bones that easily break.

platelet: A type of blood cell produced by the bone marrow. Platelets help blood coagulate in response to damage to the blood vessels.

prednisone: A drug used to treat inflammatory diseases and some forms of cancer. In the treatment of leukemia, prednisone induces cancer cells to commit suicide.

pulmonologist: A doctor with specialized training in the diagnosis and treatment of respiratory diseases.

rare disease: In the United States, a rare disease is one that affects fewer than 200,000 people.

red blood cell: A type of blood cell produced in the bone marrow. Red blood cells are responsible for transporting oxygen to the cells of the body.

Rocky Mountain spotted fever: A disease transmitted by a tick bite. Caused by a bacterial infection, Rocky Mountain spotted fever is characterized by headaches, fever, muscle pain, and skin rash.

scleroderma: A disease of the connective tissue that involves an excessive accumulation of the protein collagen. Because connective tissue is found throughout the body, features of scleroderma are observed in many different body systems.

scoliosis: A medical condition in which a person's spine shows a curve from side to side. Scoliosis may be associated with other diseases, and its symptoms range from mild to severe.

stem cell: A cell with the potential to form many of the different cell types found in the body. When stem cells divide, they can form more stem cells or other cells that perform specialized functions.

stigma: In a social setting, a public disapproval of some personal characteristic or belief that is at odds with the cultural norms.

vincristine: A drug used to treat some forms of cancer. It targets rapidly dividing cells by interfering with the action of a protein needed for cell division.

white blood cell: A type of blood cell produced by the bone marrow. White blood cells are part of the immune system and help protect the body against foreign material and infection by pathogens.

References

American Cancer Society, Cancer Reference

Chin, C., and Brown, D.E. 2002. Student-

Information. No date. Retrieved December 19,

generated questions: A meaningful aspect of
2009, from http://www.cancer.org/docroot/
learning in science. *International Journal of*
CRI/content/CRI_2_4_1X_What_are_the_
Science Education, 24(5): 521–549.
key_statistics.
Corrigan, P., Watson, A., Otey, E., Westbrook, A.,
Bell, P., and Linn, M.C. 2000. Scientific
Gardner, A., Lamb, T., et al. 2007. How
arguments as learning artifacts: Designing for
do children stigmatize people with mental
learning from the Web with KIE. *International*
illness? *Journal of Applied Social Psychology,*
Journal of Science Education, 22(8): 797–817.
3 7(7): 1405–1417.
Biological Sciences Curriculum Study. 2006.
Coté, T. 2009. The State of the Orphan Drug
The BSCS 5E Instructional Model: Origins
Act. Presentation to the Institute of Medicine
and effectiveness. Report prepared for the
Committee on Accelerating Rare Diseases
National Institutes of Health, Office of Science
Research and Orphan Product Development,
Education). Colorado Springs: BSCS.
August 12. Washington, DC.

Borchers, M.T., Harris, N.L., Wesselkamper, S.C.,
Cystic Fibrosis Foundation. 2008. Research
Zhang, S., Chen, Y., Young, L., et al. 2006.
Milestones. Retrieved August 9, 2010,
The NKG2D-activating receptor mediates
from http://www.cff.org/research/
pulmonary clearance of *Pseudomonas*
ResearchMilestones/.
aeruginosa. *Infection and Immunity, 74*(5):
2578–2584.
Delude, C. 2009. Tangier disease: One island's
treasure. Proto Magazine (Fall): 16–21.
Bransford, J.D., Brown, A.L., and Cocking, R.R.
Retrieved August 9, 2010, from
2000. *How People Learn: Brain, Mind,*
http://protmag.com/statics/tangiers.pdf.
Experience, and School. Washington, DC:
National Academy Press.
Dietz, H.C. 2009. Marfan Syndrome.
Retrieved August 9, 2010, from
Campeau, P.M., Scriver, C.R., and Mitchell, J.J.
http://www.ncbi.nlm.nih.gov/bookshelf/
2008. A 25-year longitudinal analysis
br.fcgi?book=gene&part=marfan.
of treatment efficacy in inborn errors

of metabolism. *Molecular Genetics and*

Fanciulli, M., Norsworthy, P.J., Petretto, E.,

Metabolism, 95(102): 11–16.

Dong, R., Harper, L., Kamesh, L., et al. 2007.

FCGR3B copy number variation is associated

Centers for Disease Control and Prevention. 2008.

with susceptibility to systemic, but not organ-

Schistosomiasis. Retrieved August 9, 2010,

specific autoimmunity. *Nature Genetics, 39*:

from http://www.cdc.gov/ncidod/dpd/parasites/

721–723.

schistomaisis/factsht_schistomaisis.htm.

Faurisson, F. 2004. EurordisCare2: Survey

Centers for Disease Control and Prevention.

of Diagnostic Delays, 8 Diseases, Europe.

2009. Dengue Epidemiology. Retrieved

Retrieved August 6, 2010, from http://

August 9, 2010, from http://www.cdc.gov/

archive.eurodis.org/imprimer.php3?id_

dengue/epidemiology/index.html.htm.

article=54.

Feinberg, A.P., and Williams, B.R. 2003. Wilms'

International HapMap Consortium. 2005.

tumor as a model for cancer biology. *Methods*

A haplotype map of the human genome.

in Molecular Biology, 222: 239–248.

Nature, 437: 1299–1320.

Freeman, J.L., Perry, G.H., Feuk, L., Redon, R.,

International HapMap Consortium. 2007.

McCarrol, S.A., Altshuler, D.M., et al. 2006.

A second generation human haplotype map of

Copy number variation: New insights in

over 3.1 million SNPs. *Nature, 449*: 851–862.

genome diversity. *Genome Research, 16*:

949–961.

Kaback, M., Lim-Steele, J., Dabholkar, D.,

Brown, D., Levy, N., Zieger, K., et al. 1993.

Gajdusek, D.C., Gibbs, C.J., and Alpers, M.

Tay-Sachs disease—carrier screening,

1967. Transmission and passage of

prenatal diagnosis, and the molecular era: An

experimental “kuru” to chimpanzees. Science

international perspective, 1970–1993. *Journal*

155(759): 212–214.

of the American Medical Association, 270(19):

2307–2315.

Geier, R., Blumenfeld, P.C., Marx, R.W.,

Krajcik, J.S., Fishman, B., Soloway, E., et al.

Krajcik, J., Blumenfeld, P.C., Marx, R.W.,

2008. Standardized test outcomes for students
Bass, K.M., Fredricks, J., and Soloway, E.
engaged in inquiry-based science curricula
1998. Inquiry in project-based science
in the context of urban reform. *Journal of*
classrooms: Initial attempts by middle school
Research in Science Teaching, 45: 922–939.
students. *The Journal of the Learning Sciences,*
7(3–4): 313–350.
Gonzalez, et al. 2005. The influence of CCL3L1
gene-containing segmental duplications
Kuhn, L., Kenyon, L., and Reiser, B.J. 2006.
on HIV-1/AIDS susceptibility. *Science, 307*:
Fostering scientific argumentation by creating
1434–1440.
a need for students to attend to each other's
claims and evidence. In S.A. Barab, K.E. Hay,
Harlen, W. 2001. *Primary Science: Taking*
and D. Hickey (Eds.), Proceedings of the
the Plunge, 2nd ed. Portsmouth, NH:
Seventh International Conference of the
Heinemann.
Learning Sciences (pp. 370–375). Mahwah,
NJ: LEA.
Health Canada. 2007. Health Professional

Advisory: Colonization Botulism in Adult
Leukemia and Lymphoma Society. No date.
Patients with Crohn’s Disease. Retrieved
Leukemia Facts and Statistics. Retrieved
August 10, 2008, from http://www.hc-sc.
December 19, 2009, from http://www.
gc.ca/dc-ma/more-autres/botulism-botulisme-
leukemia-lymphoma.org/all_page.adp?item_
eng.php.
id=9346.
Hickey, D.T., Kindfeld, A.C.H., Horwitz, P., and
Loucks-Horsley, S., Hewson, P.W., Love, N.,
Christie, M.A. 1999. Advancing educational
and Stiles, K.E. 1998. *Designing Professional*
theory by enhancing practice in a technology
Development for Teachers of Science and
supported genetics learning environment .
Mathematics. Thousand Oaks, CA: Corwin
Journal of Education, 181: 25–55.
Press.
Institute of Medicine, 2010. Rare Diseases and
Lupski, J., and Stankiewicz, P. 2005. Genomic
Orphan Products: Accelerating Research and
disorders: Molecular mechanisms for
Development. Washington, DC: National

rearrangements and conveyed phenotypes.

Academies Press.

PLoS Genetics, 1(6): e49.

42

Rare Diseases and Scientific Inquiry

Lynch, S., Kuipers, J., Pyke, C., and Szesze, M.

Retrieved August 11, 2008, from http://www.

2005. Examining the effects of a highly rated

nih.gov/about/researchresultsforthepublic/

science curriculum unit on diverse students:

RareDiseasesCRN.pdf.

Results from a planning grant. *Journal of*

Research in Science Teaching, 42: 921–946.

National Institutes of Health. 2008. Nocardia

Infection. Retrieved August 20, 2010, from

Massachusetts General Hospital. 2007. News

http://www.nlm.nih.gov/mdelineplus/ency/

Release: Second Phase of HapMap Project

article/000679.htm.

Is Completed. Retrieved July 24, 2008,

from http://www.massgeneral.org/news/

National Institutes of Health and Biological

releases/101707daily.html.

Sciences Curriculum Study. 2005. *The Science*

of Mental Illness. Colorado Springs: BSCS.

McKusick-Nathans Institute of Genetic
Available from http://science.education.nih.
Medicine and Johns Hopkins University.
gov/supplements/mentalsleep.
2005. Online Mendelian Inheritance in
Man. Bethesda, MD: National Center for
National Institutes of Health and Biological
Biotechnology Information, National Library
Sciences Curriculum Study. 2003. *Sleep*,
of Medicine. Available at http://www.ncbi.nlm.
Sleep Disorders, and Biological Rhythms.
nih.gov/omim/.
Colorado Springs: BSCS. Available
from http://science.education.nih.gov/
McNeill, K.L., and Krajcik, J. 2007.
supplements/sleep.
Instructional strategies to support students
writing scientific explanations. In J. Luft,
National Marfan Foundation. Retrieved July, 6
J. Gess-Newsome, and R. Bell (Eds.), *Science as*
19, 2011, from http://www.marfan.org/marfan.
Inquiry in the Secondary Setting. Washington,
DC: National Science Foundation.
National Necrotizing Fasciitis Foundation.
Quick Print Fact Sheet. Retrieved December

Minner, D.D., Jurist Levy, A., and Jeanne
19, 2009, from http://www.nnff.org/nnff.
Century, J. 2009. Inquiry-based science
instruction—What is it and does it
National Organization for Rare Disorders. No
matter? Results from a research synthesis
date. FDA Approves HDE for Rare Disorder
years 1984 to 2002. *Journal of Research in*
of Placenta. Retrieved January 18, 2011,
Science Teaching, published online at Wiley
from http://www.rarediseases.org/news/FDA_
InterScience (www.interscience.wiley.com).
approves_HDE.
National Center for Biotechnology Information.
National Organization for Rare Disorders. 2007,
2009. GENETests: Growth of Laboratory
December 4. Testimony Submitted by the
Directory. Retrieved August 4, 2010, from
National Organization for Rare Disorders
http://www.ncbi.nlm.nih.gov/projects/
Before the Social Security Administration
GeneTests/static/whatsnew/labdirgrowth.shtml.
Public Hearing on Compassionate
Allowances. Retrieved August 4, 2010, from
National Center for Education Statistics.

http://www.ssa.gov/compassionateallowances/

2011. The Nation’s Report Card: Science

NORDTestimonyCompassionateAllowances

2009. Institute of Education Sciences, U.S.

120407.pdf.

Department of Education, Washington, DC.

National Research Council. 1996. *National*

National Institutes of Health. 2010. Rare Diseases

Science Education Standards. Washington, DC:

Clinical Research Network (fact sheet).

National Academies Press.

References

National Research Council. 2000. Inquiry and

Stefansson, H., Helgason, A., Thorleifsson, G.,

the National Science Education Standards:

Steinthorsdottir, V., Masson, G., Barnard, J.,

A Guide for Teaching and Learning.

et al. 2005. A common inversion under

Washington, DC: National Academies Press.

selection in Europeans. *Nature Genetics, 37*(4):

129–137.

Office of Rare Diseases Research. 2009. Office of

rare diseases research brochure. Available at

Stranger, B.E., Forrest, M.S., Dunning, M.,

http://rarediseases.info.nih.gov/asp/resources/

Ingle, C.E., Beazley, C., Thorne, N., et al.

ord_brochure.html.

2007. Relative impact of nucleotide and

copy number variation on gene expression

Prusiner, S.B. 1982. Novel proteinaceous

phenotypes. *Science, 315*(5813): 848–853.

infectious particles cause scrapie. Science,

216: 136–144.

University of Cincinnati. 2006, September 6.

Environmental Toxins May Cause Body’s

Rados, C. 2003. Orphan products: Hope for

Defenses to Worsen Lung Disease (news

people with rare diseases. *FDA Consumer,*

release). Retrieved August 9, 2008, from

37(6). Retrieved July 31, 2008, from

http://healthnews.uc.edu/news/?/3111/.

http://www.fda.gov/fdac/features/2003/

603_orphan.html.

Watson, A.C., Otey, E., Westbrook, A.L.,

Gardner, A.L., Lamb, T.A., Corrigan, P.W.,

Sandoval, W.A., and Reiser, B.J. 1997. Evolving

et al. 2004. Changing middle schoolers’ attitudes

Explanations in High School Biology. Paper

about mental illness through education .

presented at the annual meeting of the
Schizophrenia Bulletin, 30(3): 563–572.
American Educational Research Association,
Chicago, IL.
Weiss, I.R., Pasley, J.D., Smith, P.S.,
Banilower, E.R., and Heck, D.J. 2003.
Savitsky, K., Baf-Shira, A., Gilad, S., Rotman, G.,
Looking Inside the Classroom: A Study of K–12
Ziv, Y., Vanagaite, L., et al. 1995. A single
Mathematics and Science Education in the U.S.
ataxia telangiectasia gene with a product
Chapel Hill, NC: Horizon Research.
similar to PL-3 kinase. *Science, 268*(5218):
1749–1753.
Wilson, C.D., Taylor, J.A., Kowalski, S.M., and
Carlson, J. 2010. The relative effects and
Solomon, G.M. 2005. Rare and Common
equity of inquiry-based and commonplace
Diseases in Environmental Health.
science teaching on students' knowledge,
Retrieved August 10, 2008, from the
reasoning, and argumentation. *Journal of*
San Francisco Medical Society Web
Research in Science Teaching, 47(3), 276–301.
site, http://www.sfms.org/AM/Template.

cfm?Section=Home&template=/CM/

World Health Organization. 2009.

HTMLDisplay.cfm&ContentID=1644.

Leishmaniasis: Burden of Disease. Retrieved

August 3, 2010, from http://www.who.int/

Steele, A.D., Emsley, J.G., Ozdinler, P.H.,

leishmaniasis/burden/en/.

Lindquist, S., and Macklin, J.D. 2006. Prion

protein (PrPc) positively regulates neural

Zhang, C.C., Steele, A.D., Lindquist, S., and

precursor proliferation during developmental

Lodish, H.F. 2006. Prion protein is expressed

and adult mammalian neurogenesis.

on long-term repopulating hematopoietic

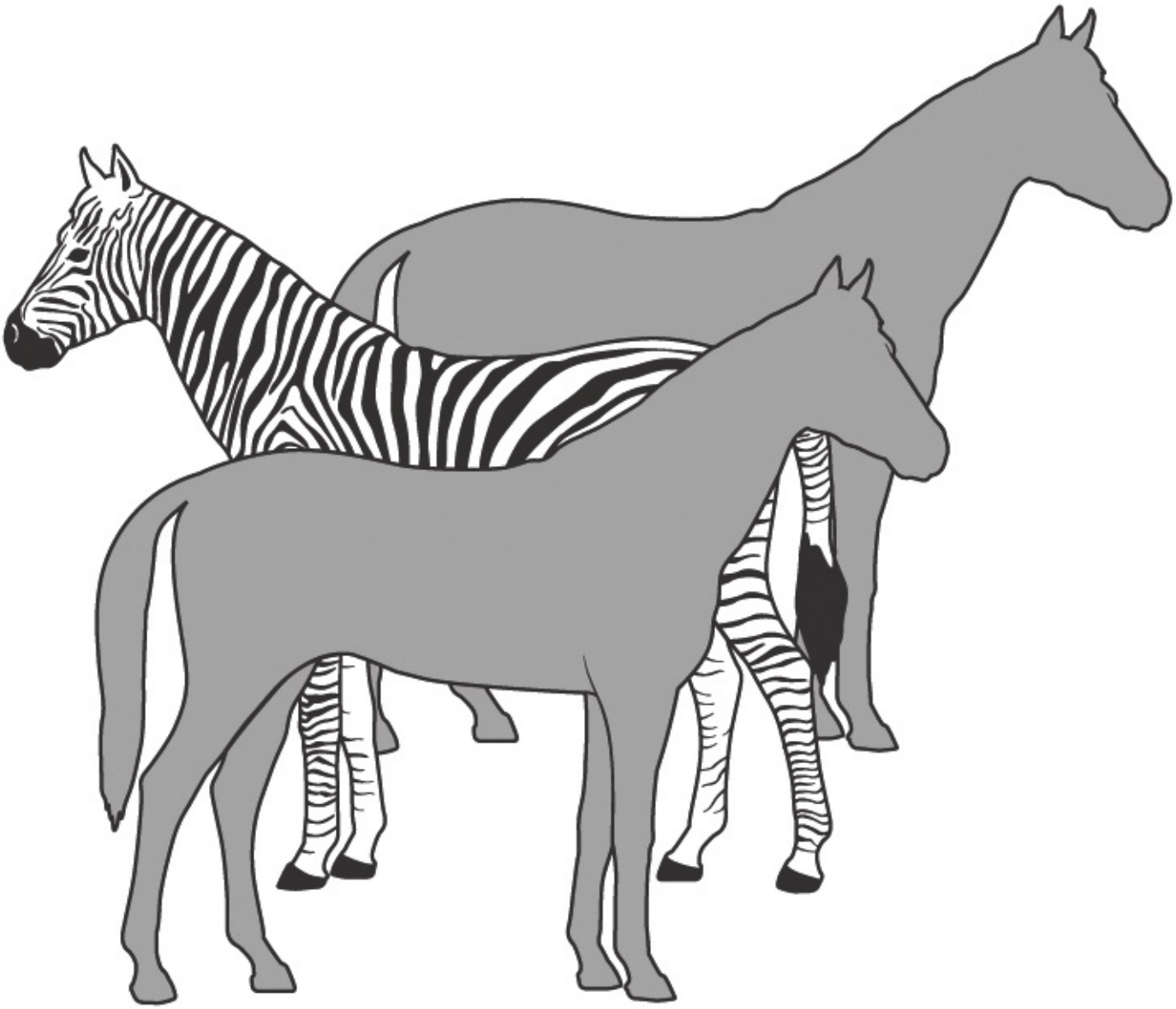
Proceedings of the National Academy of

stem cells and is important for their self-

Sciences, USA, *103*: 3416–3421.

renewal. *Proceedings of the National Academy*

of Sciences, USA, 103: 2184–2189.



Lesson 1

What Is a Rare Disease?

1

2

Engage

At a Glance

Overview

Lesson 1 asks students to consider their feelings about rare diseases and **3**

their attitudes toward people affected by a rare disease. Students are

presented with a fictional scenario in which a reality TV show is thinking about filming a student with a rare disease joining the class. A short list of questions elicits students' preconceptions about disease and its causes.

Students distinguish between diseases that can be cured and those that

can be controlled.

Major Concepts

• Diseases have three main causes:

4

– genetics,

– environmental exposure, and

– infectious agents.

• Rare diseases may become common, and common diseases may become

rare.

• Some rare diseases can be cured, while many others can be managed

through treatment.

• People with a rare disease sometimes must cope with the stigma

associated with their condition.

5

45

Objectives

After completing this lesson, students will have

• recorded their preconceptions about the nature of disease and

• considered their feelings about people who are affected by rare diseases.

Teacher Background

Consult the following sections in Information about Rare Diseases and

Scientific Inquiry:

1.0 A History of Rare Diseases in the United States (pages 21–24)

2.0 The Impact of Genomics on Rare Diseases (pages 24–26)

3.0 Rare Infectious Diseases (page 26)

4.0 Rare Diseases Caused by Environmental Toxins (pages 27–28)

In Advance

Web-Based Activities

Activity

Web Component?

1

No

Photocopies, Transparencies, Equipment, and Materials

Photocopies and Transparencies

1 transparency of Master 1.1

1 copy of Master 1.2 **for each student**

Equipment and Materials

None

Preparation

Each student will need to maintain a notebook or folder dedicated

to this supplement. Most lessons involve handouts and ask students to record information in their notebooks. The lessons also include

opportunities for students to record their initial ideas and answers to questions about rare diseases and scientific inquiry. To help them monitor their own understandings and track how their thinking has changed,

students will frequently refer back to their previous work and their initial understandings. Decide what format will work best for your students. If your students normally use bound composition books, they can continue

to use these and tape or staple handouts into the book. Alternatively,

students can use notebook paper for their writing, and then keep their

notes and their handouts in binders or folders.

46

Rare Diseases and Scientific Inquiry

Procedure

Activity 1: *What Is a Rare Disease?*

Estimated time: 50 minutes

1

Note: During this lesson, students have an opportunity to express their initial ideas about rare diseases and consider their feelings toward people who are coping with rare diseases. The lesson begins with a reality TV

show scenario where a student with a rare disease is about to join the

class. The aim of this scenario is to bring the idea of rare diseases into students' lives. The intent of the lesson is not to teach content about rare diseases and their causes and management, but rather to elicit students'

prior knowledge about rare diseases. Responses to the questions posed

during the lesson can help you assess students' relative familiarity with the concepts and identify misconceptions. Intended to be brief, this

initial assessment of preconceptions can help you adjust your teaching of **2**

Lessons 2 through 5.

1.

Begin the lesson by explaining that you have received a letter

from a television producer asking for help with a new reality TV

show his production company is developing.

2.

Display Master 1.1, *Letter from a Producer*. Ask for a volunteer to read the letter aloud to the class.

The letter explains that a proposed reality TV show will take place

in a middle school and involve a class that includes one student

3

who has a rare disease. The show will give viewers an idea of how

this student interacts with teachers and other students. The specific

nature of the disease has not yet been decided.

3.

Further explain that the principal has asked your class to help

with the producer's request. Ask,

• "How would you feel about having such a student join the

class?"

• "What questions would you want to ask before the student

arrives?"

• "What questions would you want to ask the student who has

4

the rare disease?”

Write these three questions on the board.

4.

Instruct students to record these questions and their answers to them in their notebooks. They should also record any feelings they have about the student joining their class.

This step is intended to have students briefly record their initial feelings about people with rare diseases and to elicit any questions

5

Lesson 1

47

or concerns they might have. Give students about five minutes to complete this task.

5.

After students have recorded their thoughts and questions, ask for one or two volunteers to share something they wrote in their

notebooks.

At this time, accept all answers. Do not attempt to answer the

Students' responses

students' questions or make judgments about their feelings.

to these questions

6.

Comment that the feelings expressed and the questions asked

will help you assess

are understandable and that students will be learning about

their initial attitudes

rare diseases during the remainder of this lesson and in the four

toward rare diseases

lessons that follow.

and those affected by

7.

Explain that you will begin by exploring what the word "disease"

them.

means to them. Give each student a copy of Master 1.2,

***Thinking about Disease*. Instruct students to answer the questions and carry out the task described on the handout.**

Explain that this handout is not meant to be a test. Instead,

it is designed to help students organize their thinking about

disease. Students' responses to the handout will identify their

preconceptions about disease. Give students about 10 minutes to

complete the handout.

Note: Students may ask questions that, although good, address issues that interrupt the flow of the

lesson. One strategy for honoring such questions is to establish a “parking lot” on a piece of chart paper or the board. One half of the parking lot is labeled “unanswered” and the other half is labeled “answered.”

Questions that are best answered at a later time are written on sticky notes and placed in the “unanswered” column. As questions are addressed in the activities, move the sticky notes to the answered side of the parking lot.

8.

After students have completed Master 1.2, ask for volunteers to

share their responses to Questions 1–3.

Answer key for questions on Master 1.2, *Thinking about Disease*

Content Standard C:

Disease is a

1. What is a disease?

breakdown in

Many students will respond that a disease is a sickness that results structures or functions

from an infectious agent such as a germ, bacterium, or virus. If

of an organism. Some

other causes such genetics or exposure to environmental toxins are

diseases are the result

not mentioned, do not be concerned. These other disease causes will be brought out in Question 3 and in the next lesson.

of intrinsic failures of

the system. Others are

2. How do doctors tell whether someone has a disease?

the result of damage

Students will likely think of blood or other types of laboratory tests.

by infection by other

This question also provides an opportunity to discuss different types organisms.

of disease symptoms such as fever, pain, and skin rashes.

48

Rare Diseases and Scientific Inquiry

Ask students to describe how the doctor can observe or measure

these symptoms.

3. What do you think causes disease?

Again, students likely will mention infectious agents. If they don't mention other causes, challenge them to think of a disease caused

by something other than an infectious agent. If necessary, ask

1

guiding questions to bring out the ideas that heredity and exposure to toxic substances in the environment are also causes.

9.

Ask students to report some of the diseases they listed for

Question 4 on the handout. As they respond, record and display

for the class a list of about 20 diseases. After the list is assembled, ask students to think about the causes of these diseases and

whether there are ways to group these diseases based on their

causes. Instruct students to organize the 20 diseases in their

notebooks in a way that illustrates the different causes.

2

Students may elect to make a table with the columns corresponding

to different causes and the rows corresponding to disease examples.

Some students may be concerned that a given disease could have or be influenced by more than one cause. Ask these students to consider using a graphical representation such a Venn diagram to illustrate these interactions.

Students may have listed diseases for which they don’t know the causes. This is understandable. The important part of this exercise is not to compile a lengthy list of diseases and their causes but

3

rather to give students a chance to express their preconceptions about diseases and their causes. If students ask you what causes a particular disease and you know the cause, tell them so they can classify it. If you don’t know the cause of the disease, instruct the student to put a question mark next to the disease and not to worry about classifying it by its cause.

Note: You may want to assign Step 9 (causes-of-disease organizer) as homework.

The manner in which

4

10. After students have completed the task, ask for volunteers to describe how they organized the diseases in their notebooks.

individual students

Ask each volunteer to explain the general causes of the diseases

organize the list of

and to list an example for each. Ask whether any of the diseases

diseases will help you

have more than one cause or whether any of the listed causes

assess the student's

interact with each other.

initial ideas about

diseases and their

Ask questions to clarify students' thinking, but do not correct

causes and to identify

misconceptions at this time. The three main causes of disease

(infectious agents, heredity or genetics, and exposure to

misconceptions the

environmental toxins) will be addressed in the subsequent lessons.

student may have.

5

Lesson 1

49

Environmental exposure may be somewhat confusing. One can

argue that a disease brought about by exposure to a pathogen is

environmental since the pathogen is found in the environment. For

our purpose, a disease caused by environmental exposure refers to a

nonliving agent such as radiation, heavy metals, or a toxin produced

by another organism.

11. Ask for volunteers to share their responses to Question 5.

5. What does it mean to call a disease "rare"?

Students' responses will vary. If students struggle with this question, rephrase it by asking whether some diseases affect more people

than others. You may mention that in this country, a disease is

considered to be rare if 200,000 people or fewer have it. To help students make some sense of this number, you can mention that the U.S. population was about 311 million people in 2011.

12. Ask, "Do you think that a disease that is rare always remains rare? Can a rare disease become a common disease?"

Students' responses will vary. If students don't bring it up, ask guiding questions to bring out the idea of a new infectious disease such as swine flu that begins as a rare disease and then becomes common as it spreads.

13. Ask, "Can a common disease become a rare disease?"

If a student doesn't mention this, direct the discussion to medicine's ability to control or even eradicate some diseases. You may mention polio as an example of a disease that was once common but is now rare. Smallpox has actually been extinguished.

14. Ask for volunteers to share their responses to Question 6 (whether the diseases they listed are curable, controllable, or not controllable).

For many diseases on their lists, students will not be able to say whether they are curable, controllable, or not controllable. Bring out in the discussion examples of diseases that are curable, such as many bacterial infections, and others that are controllable, such as diabetes.

15. Explain that some diseases are relatively easy to treat and others are more difficult. Ask, "What are some reasons that one disease might be more difficult to treat than another?"

Students may focus on specific diseases. Try to get them to speak in

general terms to address issues such as the amount of information

50

Rare Diseases and Scientific Inquiry

known about the disease, the ease of diagnosis, and the amount of resources that society devotes to the study and treatment of the disease.

Remind students to return Master 1.2 to their notebooks. They will revisit the ideas they recorded on the handout in a later lesson.

1

16. Conclude the lesson by remarking that the lessons that follow will give students opportunities to reflect on the ideas brought out during this lesson and to modify their thinking if necessary.

2

3

4

5

Lesson 1

51

Lesson 1 Organizer

Activity 1: *What Is a Rare Disease?*

Estimated time: 50 minutes

Page and Step

Explain that a TV producer wants to film a reality show about a student Page 47 with a rare disease joining the class. Display **Master 1.1**, and have Steps 1 someone read it aloud .

and 2

Write these questions on the board as you ask them:

Page 47

• “How would you feel about having such a student join the class?”

Step 3

• “What questions would you ask before the student arrives?”

• “What questions would you ask the student who has the rare

disease?”

Instruct students to write the answers in their notebooks.

Page 47

Step 4

Ask one or two volunteers to share their answers with the class.

Page 48

Step 5

Explain that students will be learning about rare diseases in the lessons Page 48

that follow. To begin, they will explore the nature of disease.

Steps 6

• Hand out a copy of **Master 1.2** to each student.

and 7

• Instruct students to follow the directions on the handout.

Ask volunteers to share their responses to Questions 1–3.

Page 48

Step 8

Ask volunteers to report diseases they listed for Question 4.

Page 49

• Record and display a list of about 20 diseases students mentioned.

Step 9

• Ask students whether they can group these diseases by cause.

Ask volunteers to explain how they grouped the diseases.

Page 49

Step 10

Ask volunteers to share their responses to Question 5.

Page 50

Step 11

Ask students,

Page 50

• “Do you think a disease that is rare always remains rare?”

Steps 12 and 13

• “Can a rare disease become a common disease?”

• “Can a common disease become a rare disease?”

Ask volunteers to share their responses to Question 6.

Page 50

Step 14

Explain that diseases vary in how easy they are to treat. Ask, “What are some Page 50

reasons that one disease might be more difficult to treat than another?”

Step 15

Explain that students will be reflecting on these ideas and changing

Page 51

their thinking if necessary.

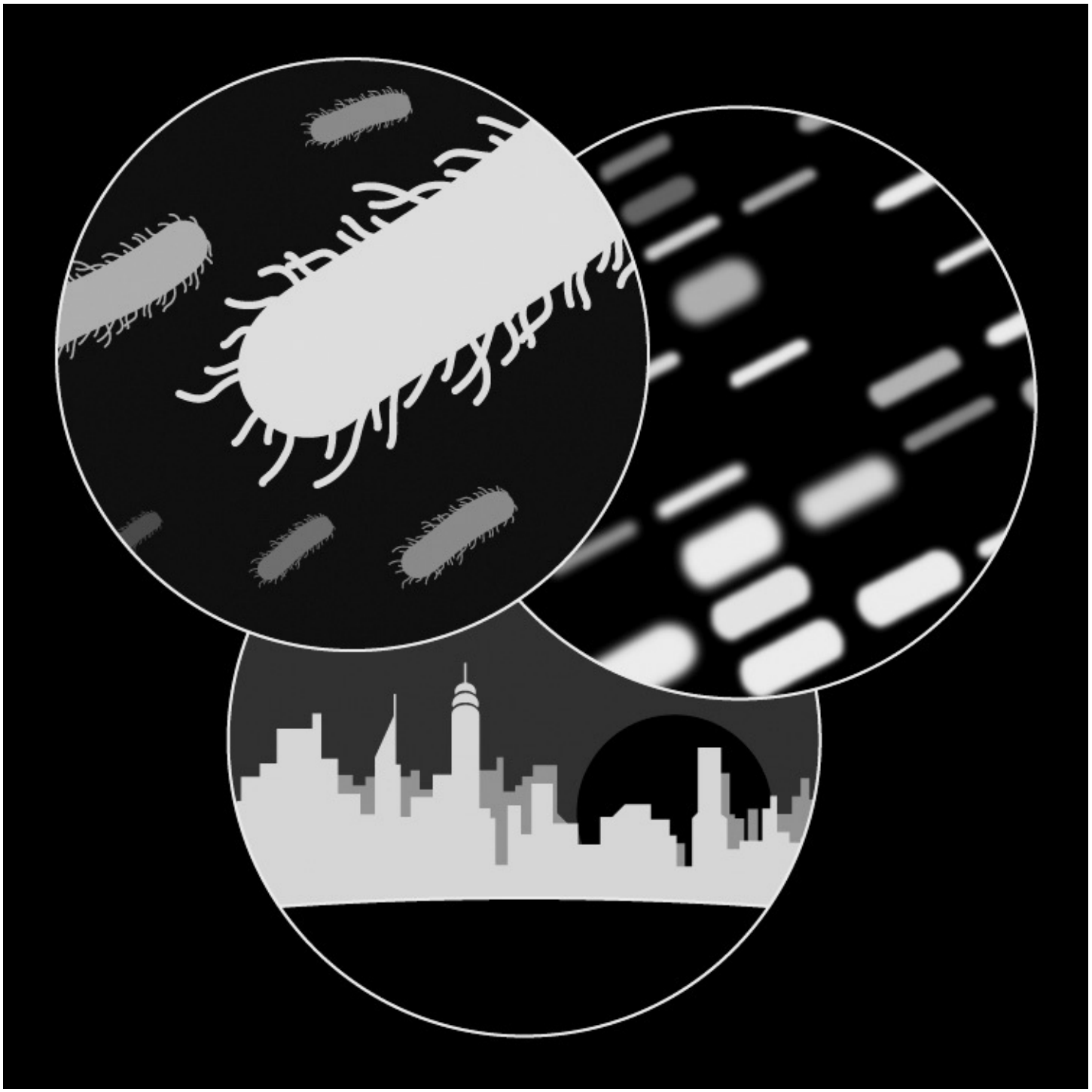
Step 16

= Involves making a transparency.

= Involves copying a master.

52

Rare Diseases and Scientific Inquiry



Lesson 2

What Causes Rare Diseases?

1

2

Explore

At a Glance

Overview

In this lesson, students assume the roles of medical officers working to protect the health of soldiers at an army post. In the course of their duties, **3**

they must consider the major causes of disease and pay special attention to infectious diseases that have the potential to spread throughout the post. One soldier becomes infected with a common bacterial species that leads to the development of a serious rare disease.

Major Concepts

• Diseases have three main causes:

– genetics,

– environmental exposure, and

– infectious agents.

4

• A bacterial species that causes a common disease can sometimes cause

a rare disease.

• Disease causes sometimes interact.

Objectives

After completing this lesson, students will have

• considered the different causes of disease,

• recognized that a single species of pathogen can cause two different

diseases depending on the route of infection, and

• discussed an example of how two different disease causes (infection

and genetics) can interact to produce a rare disease.

5

53

Teacher Background

Consult the following sections in Information about Rare Diseases and

Scientific Inquiry:

2.0 The Impact of Genomics on Rare Diseases (pages 24–26)

3.0 Rare Infectious Diseases (page 26)

4.0 Rare Diseases Caused by Environmental Toxins (Pages 27–28)

5.1 Necrotizing Fasciitis (pages 28–29)

6.0 Rare Diseases as a Topic for the Middle School Classroom (pages 33–34) **In Advance**

Web-Based Activities

Activity

Web Component?

1

Yes

2

Yes

3

No

Photocopies, Transparencies, Equipment, and Materials

Photocopies and Transparencies

Activity 1: Causes of Disease

For Classes Using Web-Based Activity:

1 transparency and 1 copy **for each pair of students** of Master 2.1

For Classes Using Print-Based Activity:

1 transparency and 1 copy **for each pair of students** of Master 2.1

1 copy of Masters 2.2 and 2.3 **for each pair of students**

Activity 2: Is a Rare Disease Present?

For Classes Using Web-Based Activity:

1 copy of Master 2.7 **for each pair of students**

For Classes Using Print-Based Activity:

1 copy of Masters 2.4, 2.5, 2.6, and 2.7 **for each pair of students**

(Optional: For Master 2.6, block out the photos before copying; see

Note on page 62.)

Activity 3: How Rare Is Rare?

None

Continued

Equipment and Materials

For Activities 1 and 2, Web-based versions, students will need

computers with Internet access.

For Activity 3, you will need baby lima beans for each group of four students:

1

• 1 small container with 9 beans and 1 bean colored red and

• 1 large container with 99 beans and 1 bean colored red.

Preparation

Activity 1

Make photocopies and a transparency.

For classes using the Web version, verify that the computer lab

is reserved for your classes or that the classroom computers

are set up for the activities. Refer to Using the Web Site for

2

details about the Web site. Check that the Internet connection

is working properly.

Log on to the Web Portion of Student Activities section of the site at

http://science.education.nih.gov/supplements/rarediseases/student

Select “Lesson 2: What Causes Rare Diseases?” so students can begin the activity right away.

3

Activity 2

Review the photos of the necrotizing fasciitis (NF) patient on Master 2.6, *Medical Reference Manual: Necrotizing Fasciitis*. **If the photo of the late-stage infection is too graphic for your students, block it out before copying.** Make photocopies.

Activity 3

Each group of four students will need

• 1 small container with 9 baby lima beans and 1 bean colored red (use

a marking pen) and

4

• 1 large container with 99 baby lima beans and 1 bean colored red (use a marking pen).

It will save time if you weigh the beans rather than count them. There are approximately 100 baby lima beans per 1.33 ounces (37.7 grams).

5

Lesson 2

55

Procedure

Note: This is an Explore lesson. It is designed to give students a common experience they can use to begin constructing understandings about rare diseases and their causes. In this lesson, students assume the roles of medical officers at an army post. This scenario gives students a real-life context in which to

consider genetics, infectious agents, and environmental exposure as the major causes of disease. The lesson focuses on the rare disease necrotizing fasciitis (NF), more commonly known as flesh-eating disease. The serious nature of this disease may be disturbing to some students. The lesson stresses that although NF is caused by a commonly encountered bacterium, the

immune system normally stops the infection before it becomes dangerous.

In rare cases (about 1 in 100,000 people), the bacteria elude the immune system and the infection can lead to organ failure and death. The hands-on probability activity is included to help make the rarity of the disease more understandable and thus reduce any student anxiety.

Activity 1: *Causes of Disease*

Estimated time: 30 minutes

1.

Explain that in this lesson, you will be concerned with this

question: What causes rare diseases?

Display this question for the class. Students should recall some

causes of disease from the first lesson. In Step 8, you may need

to remind students that there are three general causes of disease:

infectious agents, heredity (genetics), and exposure to toxins in the

environment.

2.

Open the activity by explaining that students will assume the

roles of medical officers who are in charge of looking after

the health of soldiers at an army post. The post is where new

recruits are trained.

If necessary, explain to students that an army post is where soldiers

are stationed. The soldiers live and sleep in close quarters called

barracks, which are like dormitories. When they are sick or injured,

soldiers visit a clinic called an infirmary.

3.

Arrange the students in pairs. Explain that their task as medical

officers is to examine the list of all visits to the infirmary during the previous week. They are looking for any patterns that

would indicate a health concern on the post.

For example, students should be on the lookout for any clusters of

illness or accidents that may represent a larger threat to the soldiers and limit the ability of the army post to meet its responsibilities.

(For print version, skip to Step 4-p below.)

In classrooms using the Web version of this activity:

4a-w. Give each student pair a copy of Master 2.1, *Medical Officer*

***Report Form*. Explain that students will add information to the 1**

form by accessing medical information on the post's Web site.

4b-w. Instruct student pairs to proceed to

http://science.education.nih.gov/supplements/rarediseases/

student

Students should click on "Lesson 2: What Causes Rare Diseases?"

and then "Activity 1: Infirmary Visits, Week 1."

5a-w. Instruct students to look over the reasons that each soldier

2

went to the infirmary and to think about the nature of the

causes of the soldiers' complaints.

Students can sort the patients by their patient number, location (the

barracks they live in), and medical complaint. This step should take no more than about five minutes.

5b-w. After students have had a chance to look over the information on the New Visits to the Infirmary, Week 1, table ask, "What are

two general reasons why soldiers reported to the infirmary?"

3

Students may want to respond by citing specific complaints. At

this point, simply direct the discussion to bring out the fact that

solders reporting to the infirmary were either sick or injured.

Continue with Step 6 on page 58.

In classrooms using the print version of this activity:

4-p. Give each student pair one copy each of Master 2.1,

4

Medical Officer Report Form, **and Master 2.2,** ***Visits to***

the Infirmary, Week **1. Instruct students to look over the reasons that each soldier went to the infirmary and to think**

about the nature of the causes of the soldiers' complaints.

This step should take no more than about five minutes.

5-p. After students have had a chance to look over the information in Master 2.2, ask, "What are two general reasons why soldiers

reported to the infirmary?"

5

Students may want to respond by citing specific complaints listed on the handout. At this point, simply direct the discussion to bring out the fact that solders reporting to the infirmary were either sick or injured.

6.

Acknowledge that soldiers may become injured for many different reasons. Ask, "What about sickness?" Remind the students that in Lesson 1, they came up with three general causes of disease: infectious agents, heredity (genetics), and exposure to environmental toxins. Ask, "Which of these three causes is most likely to be responsible for a health problem that can spread throughout the post?"

Students should recognize that a disease caused by an infectious agent is the most likely to spread throughout the post.

7.

Display Master 2.1. Ask for a volunteer to summarize the reasons that soldiers came to the infirmary.

Content Standard C:

Display the responses as you list them. Guide the discussion to Disease is a focus on the following:

breakdown in

• Barracks A has a cluster of six soldiers complaining of sore, itchy

structures or functions

eyes.

of an organism. Some

• Barracks G has a cluster of six solders complaining of sore throat.

diseases are the result

• Barracks E has two soldiers with a skin rash.

• Four soldiers from three different barracks have sore toes from

of intrinsic failures of

wearing new boots.

the system. Others are

• One soldier has a cut on the leg.

the result of damage

• One soldier complains of shortness of breath.

by infection by other

• One soldier twisted his ankle.

organisms.

Content Standard F:

8.

Remind students that they need to look for potential health

threats to the post. Ask, “Do you see any patterns or cases that

Natural environments

worry you?”

may contain

substances (for

Students should respond that the clusters of sore, itchy eyes; sore

example, radon and

throats; and skin rashes could each potentially spread to other

lead) that are harmful

soldiers on the post. Students may also mention the soldier in

to human beings.

Barracks I who complained of shortness of breath. The other

soldiers visiting the infirmary have problems that probably won't

spread.

9.

Mention that it is possible that one or more types of infectious disease may be present on the post. Ask, "How can we tell whether or not a soldier has a bacterial infection?"

Students' responses will vary. They may mention other symptoms such as mucous discharge or running a fever. If not mentioned by

a student, turn the discussion to laboratory tests. Students may first think of a blood test. Explain that doctors can obtain a swab from a

patient's throat or other part of the body and test it for the presence of infectious bacteria.

10. Explain that as medical officers, they have the ability to test for the presence of different species of bacteria that had previously

1

infected soldiers on the post. Two different tests can be ordered:

• Test 1: Looks for infection by bacterial species A, B, and C.

These species are associated with common infections for

pinkeye and sore throats as well as infections resulting from

cuts and abrasions.

• Test 2: Looks for bacterial infections associated with skin

rashes caused by Rocky Mountain spotted fever or Lyme

disease. Test 2 also looks for exposure to poison ivy (not

caused by bacteria).

2

Note: While it is true that medical tests sometimes look for multiple causes at the same time, the tests described in this activity were created to make the test-ordering procedure easy for students to carry out.

(For print version, skip to Step 11-p on page 60.)

In classrooms using the Web version of this activity:

11-w. Instruct students to return to the Web site in their pairs and select the lab tests (if any) to perform on the soldiers. After

making their selections, students should summarize on

3

Master 2.1 which tests they ordered, which soldiers were

tested, and why they ordered each test. Conduct a brief

discussion to reach a consensus about which tests (if any)

should be ordered and for whom.

Since the exact causes of the soldiers' illnesses are not known,

students should decide to test the solders with eye redness and

sore throats with Test 1, which looks for infection by bacterial

species A, B, and C.

4

Soldiers with skin rashes should be tested using Test 2, which

looks for infection by the bacteria associated with Rocky Mountain

spotted fever and Lyme disease as well as exposure to poison

ivy. Students may decide not to perform tests on the soldiers

complaining of sore toes. Explain that such foot blisters can

become infected and suggest that they, too, be tested for possible

infection using Test 1 (infection by bacterial species A, B, and C).

Some students may want to play it safe and order both tests for

each soldier. Make it clear that tests come with costs, and the

5

Lesson 2

59

infirmary must perform efficiently. Therefore, only needed tests

should be ordered.

Note: Pinkeye (conjunctivitis) can either be contagious or not. The contagious form of the disease is caused by a bacterial or a viral

infection. A number of different bacterial species can cause a pinkeye

infection.

12-w. Instruct student pairs to return to the Web site and click on

“Activity 1: Lab Test Results.”

The table that appears contains the same information about

soldiers visiting the infirmary that is in “Activity 1: Infirmary

Visits, Week 1." It also lists which lab tests were ordered, the lab test results, the patient diagnosis, and the patient treatment.

13-w. Instruct students to briefly summarize in their notebooks those cases with the potential to spread throughout the army post. Also ask them to describe how the cases were treated.

Students need not list information about each soldier. Instead, they can describe groups of soldiers with similar complaints and test results.

End of Web-based activity.

In classrooms using the print version of this activity:

11-p. Instruct student pairs to decide which lab tests (if any) to perform on which soldiers. Groups should summarize on Master 2.1 which tests they ordered, which soldiers were tested, and why they ordered each test. Conduct a brief discussion to reach a consensus about which tests (if any) should be ordered and for whom.

Since the exact causes of the soldiers' illnesses are not known, students should decide to test the solders with eye redness and sore throats with Test 1, which looks for infection by bacterial species A, B, and C.

Soldiers with skin rashes should be tested using Test 2, which looks for infection by the bacteria associated with Rocky Mountain spotted fever and Lyme disease as well as exposure to poison ivy. Students may decide not to perform tests on the soldiers complaining of sore toes. Explain that such foot blisters can become

infected and suggest that they, too, be tested for possible infection

using Test 1 (infection by bacterial species A, B, and C).

60

Rare Diseases and Scientific Inquiry

Some students may want to play it safe and order all tests for each

soldier. Make it clear that tests come with costs, and the infirmary

must perform efficiently. Therefore, only needed tests should be

ordered.

Note: Pinkeye (conjunctivitis) can either be contagious or not. The contagious form of the disease is caused by a bacterial or a viral infection.

1

A number of different bacterial species can cause a pinkeye infection.

12-p. Give each student pair one copy of Master 2.3, *Test Results,*

***Week 1*.**

This handout contains the same information about soldiers visiting

the infirmary that was found on Master 2.2. It also lists which lab

tests were ordered, the lab test results, the patient diagnosis, and the patient treatment.

13-p. Instruct students to briefly summarize in their notebooks those 2

cases with the potential to spread throughout the army post and

to describe how they were treated.

Students need not list information about each soldier. Instead, they can describe groups of soldiers with similar complaints and test results.

Activity 2: *Is a Rare Disease Present*?

Estimated time: 40 minutes

3

(For print version, skip to Step 1-p on page 62.)

In classrooms using the Web version of this activity:

Note: In Step 9 of this activity, students access a medical reference manual that contains two images of a patient with flesh-eating disease. One of the images is rather graphic and may be disturbing to some students. We recommend that you view the images before class and decide whether

you want students to see them. If you decide not to let students see them, instead of using the Web site for this step, give each student pair one copy **4**

of Master 2.6, *Medical Reference Manual*, on which you have blocked out the photos.

1-w. Keep the students in pairs. Explain that one week has gone by, and you are ready to discuss the patient outcomes from that

week. You are also going to present a list of new visits to the

post's infirmary.

2-w. Instruct students to proceed to

http://science.education.nih.gov/supplements/rarediseases/

student

5

Lesson 2

61

Students should click on "Lesson 2: What Causes Rare

Diseases?" and then "Activity 2: Follow-up on Week 1 Visits."

After students have had a chance to look over the information

in the table, ask for volunteers to summarize what they

learned about the treatment outcomes of the Week 1 infirmary

visits.

The cases of pinkeye, sore throat, skin rash, and asthma have responded (or are responding) to treatment. Cases of sore toes and injuries were treated, but it is too soon to describe outcomes.

3-w. Ask, "Did you learn anything that causes you to be concerned?"

Many students will probably note that the treatments are working and will, therefore, express no particular concerns. Some students may be concerned that two of the six soldiers being treated for sore throats returned to the infirmary. Others may note that three of the four soldiers who developed blisters on their feet tested positive for infection by bacterial species A.

4-w. Instruct students to click on "Activity 2: Infirmary Visits, Week 2." As before, instruct students to reflect on the information and summarize in their notebooks the soldiers' reasons for coming to the infirmary.

This step should take no more than about five minutes.

Continue with Step 5 on page 63.

In classrooms using the print version of the activity:

Note: In Step 9-p, student pairs get a copy of Master 2.6, which contains two images of a patient with flesh-eating disease. One of the images is rather graphic and may be disturbing to some students. We recommend that you view the images before class and decide whether you want students to see them. If not, block out the images on Master 2.6 before making copies.

1-p. Keep the students in their pairs. Explain that one week has

gone by and you are ready to discuss the patient outcomes from that week. You are also going to present a list of new visits to the post's infirmary.

2-p. Give each student pair one copy of Master 2.4, *Follow-up on Week 1 Infirmary Visits.*

62

Rare Diseases and Scientific Inquiry

3-p. After groups have had a chance to look over Master 2.4, ask, "Did you learn anything that causes you to be concerned?"

Many students will probably note that the treatments are working and will, therefore, express no particular concerns. Some students may be concerned that two of the six soldiers being treated for sore throat returned to the infirmary. Others may note that three of the

1

four soldiers who developed blisters on their feet tested positive for infection by bacterial species A.

4-p. Give each pair one copy of Master 2.5, *Visits to the Infirmary, Week 2*. As before, instruct students to reflect on the information on the handout and to summarize, in their notebooks, the soldiers' reasons for coming to the infirmary.

This step should take no more than about five minutes.

2

5.

Ask for volunteers to summarize the information they recorded in their notebooks.

Display students' responses as you list them. Guide the discussion to focus on the following:

Some soldiers who visited the infirmary during Week 1 returned.

• Two soldiers from Barracks G who reported to the infirmary during the first week complaining of sore throat returned with similar complaints.

3

• One of the soldiers with a sore toe has developed a severe infection from bacterial species A.

Most soldiers who visited the infirmary were first-time patients.

• Four soldiers from Barracks G appeared complaining of sore throat.

• Two soldiers from Barracks A appeared complaining of sore throat.

• Two soldiers (from Barracks B and F) appeared complaining of skin rashes.

• One soldier appeared with a cut on the head.

4

• One soldier appeared with an injured ankle.

• One soldier appeared with a sore toe.

6.

Remind students that you are concerned about infectious diseases that might spread to the rest of the post. Ask, “Is there any evidence of a bacterial infection spreading throughout the post?”

Students may observe that the infection with bacterial species C that caused the pinkeye is under control and not cause for concern. They should also observe that new cases of infection by bacterial species

5

A are sending soldiers from other barracks to the infirmary with sore throats. Some will likely report that this is a cause for concern. Finally, some students may note that bacterial species A is also responsible for a severe foot infection in one soldier who developed a blister from wearing new boots.

7.

Explain that you are concerned about the foot infection that has quickly become serious. Observe that bacterial species A seems to be responsible for two different diseases: the inflammation of the throat seen in many soldiers and the severe foot infection in one soldier. Ask, “Can the same bacterial species be responsible for causing two different diseases?”

Students will probably not be able to give a knowledgeable answer to this question. Guide the discussion to bring out the possibility

that the same bacteria infecting different parts of the body might produce different symptoms.

8.

Acknowledge that it is difficult to know whether bacterial species A can cause two very different-looking diseases. Explain that the severe foot infection could be due to flesh-eating disease, which is very rare though very serious. Suggest that some research may help discover whether there is a possible link between bacterial species A and flesh-eating disease.

Explain that students can look up flesh-eating disease in the Medical Reference Manual, which has a section on microbiology and disease.

9-w. Give each pair one copy of Master 2.7, *Questions about a Rare Disease*. Instruct students to read the information about flesh-eating disease in the Medical Reference Manual and use it to answer the questions on Master 2.7. (To get to the Web version of the manual, students should follow Step 2-w above but click on "Activity 2: Medical Reference Manual.")

Content Standard A:
Scientific explanations
emphasize evidence,
have logically
consistent arguments,
and use scientific
principles, models,
and theories.

Give students about 10 minutes to complete the tasks.

In classrooms using the print version of the activity:

Students' answers

to the questions will

9-p. Give each pair one copy of Master 2.6, ***Medical***

help you assess how

Reference Manual: Necrotizing Fasciitis**, and**

well they can use

Master 2.7, ***Questions about a Rare Disease*****. Instruct**

students to read Master 2.6 and use it to answer the questions

multiple forms of

on Master 2.7.

evidence to support a

scientific explanation.

Give students about 10 minutes to complete the tasks.

10. After students have completed the tasks, ask for volunteers to report answers to each question on Master 2.7.

Answer key for Master 2.7, ***Questions about a Rare Disease***

1. What evidence suggests that bacterial species A causes both sore

throat and foot infection?

1

• ***Bacterial species A was cultured from throat swabs of soldiers***

with sore throats and from toe swabs of three out of four soldiers

who developed blisters from wearing new boots.

• The Medical Reference Manual mentions that flesh-eating disease can be caused by different species of bacteria, including the one that causes strep throat.

2. What evidence suggests that the soldier with the foot infection has flesh-eating disease?

• A toe swab tested positive for bacterial species A.

2

• The symptoms (redness, swelling, and nausea) are consistent with flesh-eating disease, as is the timeline (symptoms progressing quickly).

3. Why are there many cases of sore throat but only one case of flesh-eating disease?

• Sore throats can spread among soldiers living together.

• Flesh-eating disease generally doesn't spread because it requires contact with an open wound.

4. What evidence is there that flesh-eating disease is a rare disease?

3

• The Medical Reference Manual states that it is rare disease. The odds of getting it are about 1 in 100,000.

• Three soldiers with foot blisters tested positive for bacterial species A, but only one soldier developed flesh-eating disease.

5. What should be the next step in treating the soldier with the foot infection? Explain your reasoning.

• The soldier should be sent immediately to a hospital with the resources needed to treat flesh-eating disease. The disease is very serious. According to the Medical Reference Manual, 2 out 10

4

patients die from it.

Activity 3: *How Rare Is Rare*?

Estimated time: 30 minutes

Note: The purpose of this activity is to make the 1 in 100,000 probability of coming down with flesh-eating disease more real to the class. It is not important that the students understand how the probability calculation is performed.

5

Lesson 2

65

1.

Observe that we all come into contact with bacterial species A and that it causes the common disease of strep throat. As this lesson shows, sometimes a bacterium associated with a common disease can also cause a rare disease. Explain that although this lesson dealt with a person who developed flesh-eating disease, the rate of this infection is actually quite low. The odds of coming down with flesh-eating disease are about 1 in 100,000.

2.

Explain that you will finish the lesson by performing a brief demonstration of the rarity of coming down with flesh-eating disease. Arrange the class in groups of four students. Give each

group

• 1 small container containing 9 baby lima beans and 1 baby

Content Standard A:

lima bean that has been colored red and

• 1 large container containing 99 baby lima beans and 1 baby

Mathematics is

lima bean that has been colored red.

important in all

aspects of scientific

3.

Display this statement: “The odds of coming down with

inquiry.

fleshing-eating disease this year are 1 in 100,000.”

4.

Explain that you will now explore that statement. Explain

that a bean colored red represents a person who *may* come down with flesh-eating disease. Instruct one student from each

group to close his or her eyes and select 1 bean from the small

container of 10 beans.

• Ask, “Did anyone get a red bean?”

Selecting the red bean means that the student *may* come down with flesh-eating disease.

5.

Display this below the statement about probability: “1/10.”

Explain that the odds of picking a red bean from the small

container were 1 in 10.

• If a student has selected the red bean, explain that it doesn’t

mean the student will get flesh-eating disease but rather that the possibility still exists.

• If no one selected a red bean, produce one yourself and explain that this represents the possibility that an individual will come down with flesh-eating disease.

6.

Instruct another student from each group to select a bean from the large container without looking.

• Ask, “Did anyone get a red bean?”

Most likely, no one will have picked a red bean.

7.

Display this next to the “1/10”: “× 1/100.” Explain that the odds of picking a red bean from the large container were 1 in 100.

• If a student has selected the red bean, explain that, as before, it doesn’t mean that the student will get flesh-eating disease but rather that the possibility still exists.

• If no one selected a red bean, produce one yourself and explain that this represents the possibility that an individual will come down with flesh-eating disease.

1

8.

Instruct students to put the bean they selected back into the large container and remix the beans.

9.

One last time, instruct another student from each group to

select a bean from the large container without looking.

• Ask, “Did anyone get a red bean?”

As before, it is unlikely that a student will have picked a red bean.

10. Display this next to the “1/100”: “× 1/100.” Explain that, just 2

as last time, the odds of picking a red bean from the large

container were 1 in 100.

11. Explain that this activity modeled the 1 in 100,000 probability of coming down with flesh-eating disease. Display the answer to

the probability calculation:

1/10 × 1/100 × 1/100 = 1/100,000

12. Summarize by explaining that to reach the 1/100,000 odds of

coming down with flesh-eating disease, a group would have had

3

to pick the red bean from the small container and pick it again

both times from the large container.

Note: Some students may wonder what it would look like to pick one red baby lima bean out of a pile of 100,000 beans. You may explain that 100,000 baby lima beans would weigh about 83 pounds and fill a large

wheelbarrow.

13. Conclude the lesson by asking,

• “What are two reasons why flesh-eating disease is so rare?”

4

• “Which two general causes of disease interacted to allow

flesh-eating disease to develop?”

Students should comment that the bacteria responsible for flesh-

eating disease are normally found in the throat and airways, but in

the case of flesh-eating disease, the bacteria enter another part of the body through an open wound.

5

Lesson 2

67

If not brought up by a student, mention that the vast majority

of people don’t develop flesh-eating disease even when infected

through an open wound. Most people’s immune systems stop the

infection; but in rare cases, a person has an immune system that

(because of genetics) allows the infection to become established.

Also, people with weakened immune systems are at higher risk for

infection.

68

Rare Diseases and Scientific Inquiry

Lesson 2 Organizer: Web Version

Activity 1: *Causes of Disease*

Estimated time: 30 minutes

Page and Step

1

Explain that students wil explore what causes rare diseases and assume the Page 56

roles of medical officers in charge of the health of soldiers at an army post.

Steps 1 and 2

Arrange the class into pairs. Explain that they will look at a list of

Page 56

infirmary visits for the previous week and look for patterns that suggest Step 3

a health concern.

Give each pair a copy of Master 2.1, and instruct pairs to go to the Page 57

Web site for the curriculum.

Step 4-w

Instruct students to click on “Activity 1: Infirmary Visits, Week 1” and to Page 57

think about the reasons why soldiers went to the infirmary.

Step 5a-w

2

Ask, “What are two general reasons why soldiers reported to the

Page 57

infirmary?”

Step 5b-w

Remind students about the three general causes of disease:

Page 58

• infectious agents,

Step 6

• heredity (genetics), and

• environmental toxins.

Ask, “Which of these three causes is most likely to be responsible for a health problem that can spread throughout the post?”

3

Display Master 2.1.

Page 58

• Ask for a volunteer to summarize the reasons that soldiers came

Steps 7

to the infirmary.

and 8

• Record and display these reasons.

• Ask, “Do any patterns or cases worry you?”

Mention that one or more types of infectious disease may be present

Page 58

on the post. Ask, “How can we tell whether or not a soldier has a

Step 9

bacterial infection?”

Explain that they can order tests for bacterial infections.

Page 59

4

• Test 1 looks for infections by bacterial species associated with

Step 10

pinkeye, sore throats, and infected cuts and abrasions.

• Test 2 looks for infections associated with skin rashes caused by

Rocky Mountain spotted fever or Lyme disease bacteria and for

exposure to poison ivy.

Instruct pairs to return to the Web site, order the needed tests, and

Page 59

record on Master 2.1 which tests they ordered and why.

Step 11-w

Ask students to click on “Activity 1: Lab Test Results.” Tell students

Page 60

to summarize in their notebooks those cases that could spread

Steps 12-w

throughout the post and to describe how they were treated.

and 13-w

5

Lesson 2

69

Activity 2: *Is a Rare Disease Present?*

Estimated time: 40 minutes

Page and Step

Explain that one week has gone by, and you are ready to discuss

Page 61

patient outcomes from Week 1.

Steps 1-w

• Instruct pairs to go the Web site and click on “Activity 2: Follow-up and 2-w

on Week 1 Visits.”

• Ask volunteers to summarize the outcomes described there.

Ask, “Did you learn anything that causes you to be concerned?”

Page 62

Step 3-w

Instruct pairs to click on “Activity 2: Infirmary Visits, Week 2” and then Page 62

to summarize in their notebooks the reasons soldiers came to the

Step 4-w

infirmary.

Ask volunteers to report what they wrote in their notebooks, display

Page 63

their responses, and discuss.

Step 5

Ask, “Is there any evidence of a bacterial infection spreading

Page 63

throughout the post?”

Step 6

Explain that you are concerned about the serious foot infection.

Page 64

• Observe that bacterial species A seems to cause both sore throats

Step 7

and the foot infection.

• Ask, “Can the same bacterial species be responsible for causing

two different diseases?”

Explain that the foot infection could be caused by flesh-eating disease.

Page 64

Instruct students to look up the disease in the Medical Reference

Step 8

Manual.

Give each pair a copy of Master 2.7 . Instruct students to go to the Page 64

Web site, click on “Activity 2: Medical Reference Manual,” and use the

Step 9-w

information there to answer the questions on Master 2.7.

Ask volunteers to report their answers to the questions

Page 65

on Master 2.7.

Step 10

70

Rare Diseases and Scientific Inquiry

Activity 3: *How Rare Is Rare?*

Estimated time: 30 minutes

Page and Step

Observe that bacterial species A is common and causes strep throat. It

Page 66

can also cause the rare flesh-eating disease. Explain that the odds of

Step 1

getting flesh-eating disease are 1 in 100,000.

1

Arrange the class in groups of four. Give each group

Page 66

• 1 small container with 9 baby lima beans and 1 baby lima bean

Step 2

colored red and

• 1 large container with 99 baby lima beans and 1 baby lima bean

colored red.

Display this statement: “The odds of coming down with flesh-eating

Page 66

disease this year are 1 in 100,000.”

Step 3

Explain that the red bean represents a person who *may* come down Page 66

with flesh-eating disease.

Step 4

2

• Have one student from each group pick a bean from the small

container without looking.

• Ask, “Did anyone get a red bean?”

Display this: “1/10.” Explain that the odds of picking a red bean were

Page 66

1 in 10.

Step 5

Have another student from each group pick a bean from the large

Page 66

container. Ask, “Did anyone get a red bean?”

Step 6

Display this next to 1/10: “× 1 /100.” Explain that the odds of picking Page 66

a red bean were 1 in 100.

Step 7

Tell students to place the selected beans back into the large container 3

Page 67

and mix. Have another student once again pick a bean from the large

Steps 8 and 9

container. Ask, “Did anyone get a red bean?”

Display next to 1 /100, “× 1 /100.” Explain that, as before, the odds of Page 67

picking a red bean were 1 in 100.

Step 10

Explain that this activity modeled the 1 in 100,000 probability of

Page 67

coming down with flesh-eating disease.

Steps 11 and 12

• Display the answer to the probability calculation:

“1/10 × 1/100 × 1/100 = 1/100,000.”

• Explain that to get flesh-eating disease, a group would have had

4

to pick the red bean from the small container and pick it again

both times from the large container.

Conclude the lesson by asking,

Page 67

• “What are two reasons why flesh-eating disease is so rare?”

Step 13

• “Which two general causes of disease interacted to allow flesh-

eating disease to develop?”

= Involves copying a master.

= Involves using the Internet.

5

= Involves making a transparency.

Lesson 2

71

Lesson 2 Organizer: Print Version

Activity 1: *Causes of Disease*

Estimated time: 30 minutes

Page and Step

Explain that students will

Page 56

• explore what causes rare diseases and

Steps 1 and 2

• assume the roles of medical officers in charge of the health of

soldiers at an army post.

Arrange the class into pairs. Explain that they will look at a list of

Page 56

infirmary visits for the previous week and look for patterns that suggest Step 3

a health concern.

Give each pair a copy of Masters 2.1 and 2.2, and ask students to read Page 57

over the reasons for the visits.

Step 4-p

Ask, “What are two general reasons why soldiers reported to the

Page 57

infirmary?”

Step 5-p

Remind students about the three general causes of disease:

Page 58

• infectious agents,

Step 6

• heredity (genetics), and

• environmental toxins.

Ask, “Which of these three causes is most likely to be responsible for a health problem that can spread throughout the post?”

Display Master 2.1.

Page 58

• Ask a volunteer to summarize the reasons that soldiers came to

Steps 7

the infirmary.

and 8

• Record and display these reasons.

• Ask, “Do any patterns or cases worry you?”

Mention that one or more types of infectious disease may be present

Page 58

on the post. Ask, “How can we tell whether or not a soldier has a

Step 9

bacterial infection?”

Explain that people can order tests for bacterial infections.

Page 59

• Test 1 looks for infections by bacterial species associated with

Step 10

pinkeye, sore throats, and infected cuts and abrasions.

• Test 2 looks for infections associated with skin rashes caused by

Rocky Mountain spotted fever or Lyme disease bacteria and for

exposure to poison ivy.

Instruct pairs to decide and then record on Master 2.1 which lab tests Page 60

(if any) to order for which soldiers and why.

Step 11-p

Give each pair a copy of Master 2.3. Ask students to summarize in Page 61

their notebooks the cases that could spread throughout the post and

Steps 12-p

to describe how they were treated.

and 13-p

72

Rare Diseases and Scientific Inquiry

Activity 2: *Is a Rare Disease Present?*

Estimated time: 40 minutes

Page and Step

Explain that one week has gone by, and you are ready to discuss

Page 62

patient outcomes from Week 1 and to present a list of new infirmary

Steps 1-p

visits. Give each student pair a copy of Master 2.4, and ask students to and 2-p 1

look it over.

Ask, “Did you learn anything that causes you to be concerned?”

Page 63

Step 3-p

Give each pair a copy of Master 2.5, and ask students to look it over.

Page 63

Instruct pairs to summarize in their notebooks the reasons soldiers

Step 4-p

came to the infirmary.

Ask volunteers to report what they wrote in their notebooks, display

Page 63

their responses, and discuss.

Step 5

Ask, “Is there any evidence of a bacterial infection spreading

Page 63

2

throughout the post?”

Step 6

Explain that you are concerned about the serious foot infection.

Page 64

• Observe that bacterial species A seems to cause both sore throats

Step 7

and the foot infection.

• Ask, “Can the same bacterial species be responsible for causing

two different diseases?”

Explain that the foot infection could be caused by flesh-eating disease.

Page 64

Instruct students to look up the disease in the Medical Reference

Step 8

Manual.

3

Give each pairs a copy of Masters 2.6 and 2.7 . Instruct students to use Page 64

Master 2.6 to answer the questions on Master 2.7.

Step 9-p

Ask volunteers to report their answers to the questions on

Page 65

Master 2.7.

Step 10

4

5

Lesson 2

73

Activity 3: *How Rare Is Rare?*

Estimated time: 30 minutes

Page and Step

Observe that bacterial species A is common and causes strep throat. It

Page 66

can also cause the rare flesh-eating disease. Explain that the odds of

Step 1

getting flesh-eating disease are 1 in 100,000.

Arrange the class in groups of four. Give each group

Page 66

• 1 small container with 9 baby lima beans and 1 baby lima bean

Step 2

colored red and

• 1 large container with 99 baby lima beans and 1 baby lima bean

colored red.

Display this statement: “The odds of coming down with flesh-eating

Page 66

disease this year are 1 in 100,000.”

Step 3

Explain that the red bean represents a person who *may* come down Page 66

with flesh-eating disease.

Step 4

• Have one student from each group pick a bean from the small

container without looking.

• Ask, “Did anyone get a red bean?”

Display this: “1/10.” Explain that the odds of picking a red bean were 1

Page 66

in 10.

Step 5

Have another student from each group pick a bean from the large

Page 66

container. Ask, “Did anyone get a red bean?”

Step 6

Display this next to 1/10: “× 1 /100.” Explain that the odds of picking a Page 66

red bean were 1 in 100.

Step 7

Tell students to place the selected beans back into the large container Page 67

and mix. Have another student once again pick a bean from the large

Steps 8 and 9

container. Ask, “Did anyone get a red bean?”

Display next to 1 /100, “× 1 /100.” Explain that, as before, the odds of Page 67

picking a red bean were 1 in 100.

Step 10

Explain that this activity modeled the 1 in 100,000 probability of

Page 67

coming down with flesh-eating disease.

Steps 11 and 12

• Display the answer to the probability calculation:

“1/10 × 1/100 × 1/100 = 1/100,000.”

• Explain that to get flesh-eating disease, a group would have had to pick the red bean from the small container and pick it again both times from the large container.

Conclude the lesson by asking,

Page 67

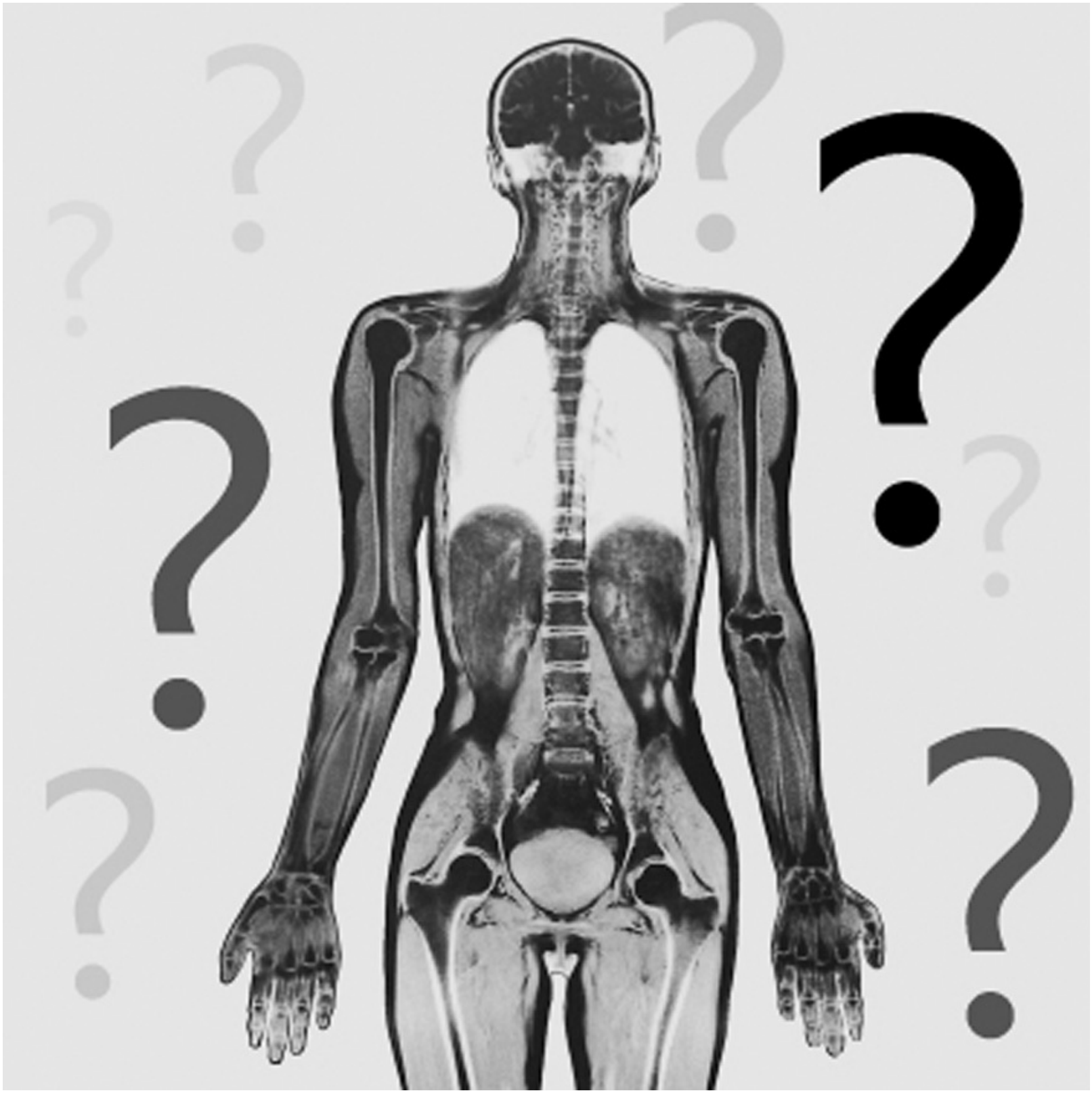
• “What are two reasons why flesh-eating disease is so rare?”

Step 13

• “Which two general causes of disease interacted to allow flesh-eating disease to develop?”

= Involves copying a master.

= Involves making a transparency.



Lesson 3

The Difficulty of Diagnosis

1

2

Explain

At a Glance

Overview

3

Some people who have a rare disease struggle to obtain a proper diagnosis.

In Lesson 3, students become involved with a case study of a boy with the rare genetic disease Marfan syndrome. Because Marfan syndrome shares

symptoms with other, more-common diseases, it can take a long time for

patients to receive the correct diagnosis. Students observe how problems with a single gene can affect many different body systems. The lesson

concludes with students considering comments made by young people

with Marfan syndrome.

Major Concepts

• Because some rare diseases have symptoms similar to more-common

4

diseases, obtaining a correct diagnosis can be difficult.

• A rare disease may have a genetic cause.

• A rare disease, like some common diseases, may affect many different

body systems at the same time.

• People with rare diseases may sometimes be viewed as being “different”

by their peers and other members of society.

Objectives

After completing this lesson, students will have

• observed how problems in a single gene can affect many different body systems,

5

75

• encountered the difficulty often associated with diagnosing a rare

disease, and

• recognized that people affected by Marfan syndrome face challenges in their lives, and despite these challenges, they have the same hopes and dreams as others and perhaps a unique view about the value of health.

Teacher Background

Consult the following sections in Information about Rare Diseases and

Scientific Inquiry:

2.0 The Impact of Genomics on Rare Diseases (pages 24–26)

5.2 Marfan Syndrome (pages 29–31)

In Advance

Web-Based Activities

Activity

Web Component?

1

Yes

2

No

3

Yes

Photocopies, Transparencies, Equipment, and Materials

Photocopies and Transparencies

Activity 1: A Parent's Dilemma

For Classes Using the Web-Based Version:

1 transparency of Master 3.1

1 copy of Master 3.2 for each student

For Classes Using the Print-Based Version:

1 transparency of Master 3.1

1 copy of Master 3.2 for each student

1 copy of Masters 3.3, 3.4, 3.5, and 3.6 for each group of 4 students (each group member gets a different master)

Activity 2: Connective Tissue

1 transparency of Master 3.7

Activity 3: A Common Thread

For Classes Using the Web-Based Version:

1 copy of Master 3.8 for each pair of students

For Classes Using the Print-Based Version:

1 copy of Masters 3.8, 3.9, and 3.10 for each pair of students

1 transparency of Master 3.11

Equipment and Materials

For Activities 1 and 3, the Web-based versions, you'll need computers 1

with Internet access.

For Activity 2, you'll need, per student pair:

• 1 new (never-before-stretched) rubber band from a dish labeled "A"

• 1 previously stretched rubber band from a dish labeled "B"

• 1 paper clip

• 1 soda can containing about 2 ounces of water*

• 1 meter stick

***Any weight of 2–3 ounces (55–85 grams) that can be easily attached to**

the paper clip will work.

2

Preparation

Activity 1

For classes using the Web version, verify that the computer

lab is reserved for your class or that classroom computers

are set up for the activities. Refer to Using the Web Site for

details about hardware and software requirements for the

Web site. Check that the Internet connection is working properly.

Log on to the Web Portion of Student Activities section of the Web site: 3

http://science.education.nih.gov/supplements/rarediseases/student

Select "Lesson 3: The Difficulty of Diagnosis."

Activity 2

Each pair of students will need a meter stick, a rubber band that has been repeatedly stretched (about 25 times), and a rubber band that hasn't been stretched. Use the same color rubber band

for both stretched and nonstretched 4

rubber bands so they look identical. Place the nonstretched rubber bands into a dish labeled “A” and the stretched rubber bands into a dish labeled “B.”

Activity 3

For classes using the Web version, verify that the computer

lab is reserved for your class or that classroom computers

are set up for the activities. Set the computers to the

opening screen for Activity 3, as you did for Activity 1.

5

Lesson 3

77

Procedure

Note: This is an Explain lesson. It is designed to build on students’

common experience learning about the causes of rare diseases. Students

assume the roles of staff working for a medical geneticist. The scenario gives students a chance to apply their understandings about disease and scientific inquiry to explain the underlying cause of diverse symptoms

displayed by a patient. In this lesson, students will use what they learned in the first two lessons about diagnosing disease. At this point, students should be able to construct more strongly supported explanations. They

should focus on scientific principles as opposed to simply expressing their ideas and offering preliminary explanations.

We chose Marfan syndrome for this lesson because it is a rare disease

caused by mutations in a single gene. It affects different body systems and can be difficult to diagnose. Patrick, the fictional patient, is a teenager who wants to play sports but has medical problems that cause his parents to worry about his participation. This realistic scenario is designed to be engaging to middle school students.

The mutations associated Marfan syndrome affect connective tissue.

Realizing that students have little knowledge about connective tissue and its functions, we designed Activity 2 to give students a simple model that illustrates how the connective tissue of

people with Marfan syndrome

differs from that of healthy people.

Activity 1: *A Parent's Dilemma*

Estimated time: 25 minutes

1.

Begin the lesson by explaining that you will investigate a case study of a child who has a rare disease. In addition to the difficulty of obtaining a correct diagnosis, students will see how patients and their families cope with this particular rare disease.

2.

Display Master 3.1, *To Play or Not to Play?* Ask for different volunteers to read each paragraph aloud to the class.

3.

Ask students to place themselves in the position of Patrick's parents and then ask, "Would you allow Patrick to try out for the basketball team?"

Students' responses will vary. Many students will conclude that Patrick should be allowed to play basketball since none of the doctors said that he shouldn't play. Some students may know of a friend or family member with one of the conditions described and base their opinion on that example. At this time, don't express an

opinion yourself about whether Patrick should be allowed to play basketball.

Tip from the field test: Consider taking a poll of the students in the class. Ask how many would allow Patrick to play basketball. Later, at the end of the lesson, poll students again and discuss why their

1

opinions have changed or stayed the same.

4.

Comment that this discussion about playing basketball and health prompted Patrick's parents to look into the family's medical history. Especially on his father's side of the family, some relatives have had medical problems similar to Patrick's. Several have had serious heart problems. The parents are worried that an inherited disease might run in the family.

2

If necessary for your students, relate the idea of inherited disease to genes and mutations. You may need to explain that some diseases that run in families are caused by mutations to a single gene and that by looking at a family tree, doctors can sometimes see

evidence for a genetic cause for the disease. This connection will be important later in the lesson.

5.

Explain that Patrick and his parents next visited a medical geneticist, a doctor who specializes in diagnosing people with genetic diseases. A medical geneticist works with other doctors

3

when it appears that a patient's disease may have a genetic cause.

Content Standard C:

Every organism

Again, if necessary, you may want to explain that many (though not all) genetic diseases are rare. This means that a family doctor may

requires a set of

never have seen a patient with the rare disease and not think of it

instructions for

when making a diagnosis.

specifying its traits.

Heredity is the

6.

Explain that for the rest of Activity 1, students will work in

passage of these

groups of four. They will assume the roles of medical specialists

instructions from one

assisting the medical geneticist in diagnosing Patrick. Because

4

generation to another.

Patrick has medical problems that affect different body systems,

each member of the group will be responsible for a different

body system. The four specialties (and their body systems)

are

• orthopedist (skeletal system),

• ophthalmologist (visual system),

• cardiologist (heart and circulation system), and

• pulmonologist (respiratory system).

5

Lesson 3

79

Note: During Lesson 5, students will create an informational poster about either Marfan syndrome or childhood leukemia. With this in

mind, you might want to stress the need to take good notes during

Lessons 3 and 4.

Content Standard C:

The human organism

has systems for

(For print version, skip to Step 7-p on page 81.)

digestion, respiration,

In classrooms using the Web version of the activity:

reproduction,

circulation, excretion,

7-w. Give each student one copy of Master 3.2, *Medical Specialty*

movement, control,

***Report Form.* Direct students to their computer stations.**

and coordination,

and for protection

Web browsers should be at

from disease. These

http://science.education.nih.gov/supplements/rarediseases/student

systems interact with

each other.

This is a menu page that contains a link for this activity.

8-w. Instruct students to click on “Lesson 3: The Difficulty of

Diagnosis,” and then “Activity 1: A Parent’s Dilemma.” Then they

should click on one of the medical specialties (“Activity 1:

Orthopedist,” “Activity 1: Ophthalmologist,” “Activity 1:

Cardiologist," or "Activity 1: Pulmonologist").

Each group member must obtain information about Patrick that corresponds to the medical specialty the group is assigned. Each medical specialty contains a report from Patrick's doctor. To help them make sense of this report, each medical specialty includes a link to a Medical Reference Manual: Disorders of Connective Tissue, which provides helpful background information. If you have enough computers for each student, then the process will move quickly.

9-w. Explain that information about Patrick's medical history and physical exam is provided for each medical specialty. Instruct students to

• review their assigned medical specialty;

• record on Master 3.2 what they learn about Patrick's medical history;

• record on Master 3.2 what they learn from Patrick's physical exam; and

• use the Medical Reference Manual to learn about possible causes of Patrick's medical problem, and then record them on Master 3.2.

Continue with Step 10 on page 81.

In classrooms using the print version of the activity:

7-p. Give each student one copy of Master 3.2, *Medical*

Specialty Report Form.

8-p. Give each group one complete set (four masters total) of these masters about Patrick's physical and medical history:

1

• Master 3.3, *Heart and Circulatory System*

• Master 3.4, *Visual System*

• Master 3.5, *Respiratory System*

• Master 3.6, *Skeletal System*

Each group member receives a set of handouts corresponding to that

person's assigned medical specialty. The information in the Medical

Reference Manual section of each handout should help students

make some sense of this information.

9-p. Instruct students to

Content Standard A:

2

• read the information on the handouts,

Students should base

• record on Master 3.2, the patient form, what they learn about

their explanations on

Patrick’s medical history,

what they observed,

• record on Master 3.2 what they learn from Patrick’s physical

and as they develop

exam, and

cognitive skills,

• use the Medical Reference Manual section from each handout

to learn about possible causes for Patrick’s medical problem

they should be

and record them on Master 3.2.

able to differentiate

explanation from

10. Give students about 20 minutes to complete the task. Then,

description—providing

3

re-form the groups and instruct students in each group to

causes for effects

• share their findings with each other and

and establishing

• discuss whether they believe that Patrick’s various medical

problems are connected and what evidence they have to

relationships based

support their conclusions.

on evidence and

logical argument.

Students should be able to use specific information from the doctors' reports and from the Medical Reference Manual to support their conclusions.

11. Ask for volunteers from each group to share their conclusions

about whether Patrick's various medical problems are connected. Students should see a pattern: Patrick has problems with four different body systems. For each body system, the Medical Reference Manual mentions that the problem may be associated with connective tissue or, more specifically, with Marfan syndrome or Ehler-Danlos syndrome.

12. Congratulate the groups on their good work and agree that there might be a common cause for Patrick's medical problems that involves connective tissue.

Lesson 3

81

Activity 2: *Connective Tissue*

Estimated time: 25 minutes

1.

Ask, "What is connective tissue?"

Content Standard A:

Different kinds

Students will probably not be able to answer this question. Since

the name is descriptive, some students may venture guesses that

of questions

connective tissue somehow holds parts of the body together.

suggest different

Accept all answers and explain that you will investigate the role of

kinds of scientific

connective tissue in this and the next activity.

investigations.

Some investigations

2.

Explain that connective tissue is largely made of proteins.

Further explain that it forms tissues that help hold organs in

involve observing

place, and it connect muscles to bones and bones to bones.

and describing

objects, organisms, or

Note: You may point out to students that our skin is largely made of events; some involve

connective tissue and that this allows the skin to be elastic—capable of collecting specimens;

stretching. Also mention that as we age, the elasticity of skin decreases.

some involve

You can simply demonstrate this by asking students to pinch some of the skin on the back of their hands and notice how long it takes the skin to experiments; some

return to its normal position. Then, repeat the demonstration using your involve seeking more

own hand. Because you are older, the skin on your hand will take longer information; some

to return to its normal position.

involve discovery

of new objects and

3.

Explain that for this demonstration, rubber bands will represent

connective tissue. Each student pair will compare the elasticity

phenomena; and

(or looseness) of two rubber bands.

some involve making

models.

4.

Display Master 3.7, *Measuring Elasticity*. Read the instructions aloud and make sure that students understand how to perform

the elasticity measurements.

5.

Arrange the students in pairs. Give each pair

• 1 meter stick

• 1 rubber band from dish A (nonstretched)

• 1 paper clip

• 1 soda can containing about 2 ounces of water (or other

2–3-ounce weight)

6.

Instruct pairs to record in their notebooks

• the question they are investigating and

• how far down the meter stick the rubber band stretched.

Pairs should write in their notebooks a question such as, “Is one rubber band more elastic than the other?” Give students about five minutes to complete the measurements.

7.

Collect the rubber bands from each pair and set them aside. Next, give each pair one rubber band from dish B (previously

stretched). Instruct students to make and record measurements as before.

8.

After students have made and recorded their measurements, ask for volunteers to state their conclusions. Specifically, ask if the two rubber bands performed the same or differently—and if differently, how so.

1

Students should report that rubber band B (the previously stretched one) stretched further than rubber band A (the nonstretched one).

9.

Explain that the rubber band from dish A (the nonstretched one) represents normal connective tissue. Ask, “What do think the rubber band from dish B represents?”

Students may have trouble answering this question. If so, guide the discussion to Patrick and the possible association of his symptoms

2

to connective tissue. Before moving on, make sure students

understand that rubber band B represents the connective tissue in a

person whose cells contain DNA that has a mutation that causes the

connective tissue to be looser than it should be.

10. Ask, “How might looser connective tissue affect the body? Think about Patrick and his medical problems.”

Mentioning Patrick may cause students to bring up mitral valve

prolapse or a dislocated eye lens. If not described by a student, ask

guiding questions to bring out the role of connective tissue. For

3

example, the looser connective tissue causes the heart valve flaps

to change shape and not make a tight seal, or the looser connective

tissue can’t hold the eye lens tightly in place.

11. Explain that in the final activity of the lesson, students will return to Patrick and his family and investigate whether he may

have a rare disease affecting his connective tissue.

Activity 3: *A Common Thread*

4

Estimated time: 25 minutes

1.

Remind students that in the previous analysis they found that

Patrick’s medical symptoms involve more than one body system

and that these symptoms seem to be related to connective

tissue. Explain that they will now investigate some disorders

that affect connective tissue and try to decide whether one rare

disorder is more likely than the others to be responsible for

Patrick's medical condition.

5

Lesson 3

83

In classrooms using the Web version of the activity:

2-w. Arrange the class into pairs. Give each pair one copy of Master 3.8, *Diagnosing a Connective Tissue Disorder*.

3-w. Direct the student pairs back to their computers. Instruct them to click on "Lesson 3: The Difficulty of Diagnosis," then "Activity 3: A Common Thread," and then "Activity 3: Medical Reference Manual."

Students should follow the instructions on Master 3.8 to compare Patrick's medical symptoms to those expected for four different disorders of connective tissue. Give students about 10 minutes to complete the tasks.

In classrooms using the print version of the activity:

2-p. Arrange the class into pairs. Give each pair one copy of Master 3.8, *Diagnosing a Connective Tissue Disorder*, and one copy of Master 3.9, *Medical Reference Manual:*

Disorders of the Connective Tissue.

3-p. Instruct student pairs to follow the instructions on Master 3.8 to compare Patrick's medical symptoms with those expected for four different disorders of connective tissue. Allow about 10 minutes for students to complete the tasks.

4.

After students have finished, ask for volunteers to report their conclusions.

Students should report that, although some of Patrick's symptoms fit more than one disorder, virtually all of his symptoms are consistent with Marfan syndrome.

Patrick's medical history

Ehlers-Danlos syndrome

Marfan syndrome

Osteogenesis imperfecta

Scleroderma

Myopia

Yes

Detached eye lens

Yes

Asthma

Yes

Collapsed lung

Yes

Heart murmur

Yes

Leaky heart valve

Yes

Yes

Long arms and legs

Yes

Curvature of spine

Yes

Yes

84

Rare Diseases and Scientific Inquiry

5.

Agree that Marfan syndrome is the best explanation for Patrick's

symptoms. Ask,

• "What is the cause of Marfan syndrome?"

• "What evidence is there to suggest that Patrick may have

Marfan syndrome?”

Students should recall that Marfan syndrome runs in families and

1

results from mutations in a gene that codes for a connective tissue protein.

Students should report that Patrick has many of the Marfan symptoms listed in the Medical Reference Manual.

In classrooms using the Web version of the activity:

6-w. Explain that to complete Patrick’s diagnosis, you want to see whether there is evidence of Marfan

2

syndrome in Patrick’s family. Direct the student pairs back to their computers and instruct them to click on “Lesson 3: The Difficulty of Diagnosis,” then “Activity 3: A Common Thread,” and then “Patrick’s Family Tree.” Students should look at the information about Patrick’s family and record in their notebooks any evidence they find that suggests a history of Marfan syndrome in the family.

Students can roll over or tab through photos of each family member and read a brief description of the person’s medical

3

history. They will see a diagram of a family tree that shows only the father’s side of the family. If students ask about the mother’s side, explain that it is free of medical symptoms associated with connective tissue disorders and, therefore,

not of interest.

Students also may notice that that Patrick has six uncles but no

aunts. They may conclude that Marfan syndrome is sex-linked.

This is a real family tree, and it's just by chance that the family tree has so many males.

4

In classrooms using the print version of the activity:

6-p. Explain that to complete Patrick's diagnosis, you

want to see if there is evidence of Marfan syndrome

in Patrick's family. Give each student pair one copy of

Master 3.10, *Patrick's Family Tree*. Instruct students to look at the information about Patrick's family and record in their

notebooks any evidence they find that suggests a history of

Marfan syndrome in the family.

5

They will see a diagram of a family tree that shows only the father's side of the family. If students ask about the mother's side, explain that it is free of medical symptoms associated with connective tissue disorders and therefore not of interest.

Students also may notice that Patrick has six uncles but no aunts. They may conclude that Marfan syndrome is sex-linked. This is a real family tree, and it is just by chance that the family tree has so many males.

7.

After students have finished, remind them of the three major causes of disease: infectious agents, heredity (genetics), and exposure to environmental toxins. Ask,

• "Did you find any evidence of Marfan syndrome in Patrick's family?"

• "Is there evidence to suggest that Patrick's symptoms may have a different cause?"

The process of

Give students 5–10 minutes to complete the task. Students should report that Patrick's father, two uncles, and grandfather have had

diagnosing Patrick

heart problems. Heart problems have many causes other than

with Marfan

Marfan syndrome; however, students should also note that other

syndrome requires

Marfan-related symptoms are mentioned such as scoliosis, a

students to apply

detached eye lens, and a collapsed lung.

understandings about

scientific inquiry. You

Some students may believe that Patrick's symptoms come from

can assess these

another cause. As in Lesson 2, they may mention that people

living in close quarters can pass on infections or may be exposed

understandings by

to the same environmental toxins. Acknowledge the truth of these

noting how well

observations, but point out that the members of Patrick's extended

students sift through

family did not live together.

various forms of

evidence to find

8.

Explain that today, an early diagnosis of Marfan syndrome allows

what is relevant

people to take steps to protect their health and live long lives. Ask,

"In what ways might having Marfan syndrome affect your life?"

to answering the

question. Also note

Students' responses will vary. If necessary, remind students of the

how well students

symptoms of Marfan syndrome and ask how these symptoms would

evaluate alternative

affect their daily lives.

explanations for

Patrick's symptoms.

In classrooms using the Web version of the activity:

9-w. Conclude the lesson by explaining that students

will now watch a brief video of young people who

have Marfan syndrome discussing their experiences. Instruct

students to first write in their notebooks some questions they

would like to ask a person with Marfan syndrome about what

it is like to live with the condition.

10-w. Direct students to their computers and instruct them to click

on "Lesson 3: The Difficulty of Diagnosis," then "Activity 3: A

Common Thread," and then "Activity 3: Patient Video."

The video is brief, just 3.5 minutes long. If you have the ability to

project the computer image, it may be simpler to watch the video

1

as a class.

11-w. After students have watched the video, reconvene the class.

Ask for volunteers to describe their reactions to the video and

how it addressed (or did not address) the questions they wrote

in their notebooks.

The video will not answer all of the questions asked by the

students. Suggest that they perform a Web search to access

information from foundations and patient support groups that can

answer their questions.

2

Note: Students could also explore the Marfan syndrome section of the Positive Exposure site (www.positiveexposure.org/marfan.html). Fashion

photographer, Rick Guidotti and Diane McLean, MD, PhD, MPH wanted

to share the beauty of rare disease patients, so, in 1997, they founded Positive Exposure, starting with photos of some people with albinism.

The site now features people with almost 30 diseases.

Tip from the field test: If you took a poll of the

students in the class at the beginning of the lesson,

3

take another now. Discuss why their opinions have

changed or stayed the same.

End of Web-based activity.

In classrooms using the print version of the activity:

9-p. Conclude the lesson by explaining that students will

now consider how Marfan syndrome affects the lives

of those who have it. Ask students to take a moment to reflect

4

on what they have learned about Marfan syndrome. Instruct

them to write down in their notebooks

• one question they would ask a doctor about having Marfan

syndrome and

• one way they think having Marfan syndrome might affect

their lives.

10-p. After students have completed the tasks, ask for volunteers to report what they wrote in their notebooks.

5

Consider displaying a couple of questions and comments that

students wrote in their notebooks.

Lesson 3

87

Tip from the field test: If you took a poll of the

students in the class at the beginning of the lesson, take

another now. Discuss why their opinions have changed

or stayed the same.

11-p. Display Master 3.11, *Living with Marfan Syndrome*. Explain that this master includes some comments from teenagers who have

Marfan syndrome. Give students a couple of minutes to read the

master.

Reveal the questions and comments on Master 3.11 one at a time, as

you talk about them.

12-p. Instruct students to reflect on the questions and comments from the young people who have Marfan syndrome. Ask,

• "Were their questions and comments similar to or different

from yours?"

• "How would you want to be treated by your classmates if you

had Marfan syndrome?”

Answer key for questions on Master 3.11, *Living with Marfan*

Syndrome

1. “Is there any possible way for the Marfan gene to be detected

before a child is born and maybe find a way to prevent it from

mutating itself?”

At present, prenatal testing is not available for Marfan syndrome.

The mutated gene associated with Marfan syndrome is found in

every cell of the body. Today’s technology cannot replace the mutated gene with a nonmutated gene.

2. “When they measured my heart with the echocardiogram, they

told my mom they don’t think I should do marching band. I was

wondering, if I don’t exert myself too much, if I take it at my

own pace, do you think I will still be able to do it?”

The student asking the question was advised that she might be able

to continue with marching band if after a practice or a performance, she didn’t feel exhausted and wasn’t short of breath and sweating.

Lesson 3 Organizer: Web Version

Activity 1: *A Parent's Dilemma*

Estimated time: 25 minutes

Page and Step

1

Explain that you will explore a case study about a child who has a

Page 78

rare disease. Display Master 3.1. Ask volunteers to read paragraphs aloud Steps 1

to the class.

and 2

Ask, "Would you allow Patrick to try out for the basketball team?"

Page 78

Step 3

Explain that Patrick's parents looked into their family history and found Page 79

relatives on his father's side who have had medical problems similar to Step 4

Patrick's.

Explain that the family visited a medical geneticist to see if Patrick's Page 79

2

problems have a genetic cause.

Step 5

Explain that students will assume the roles of medical specialists and

Page 79

work in groups of four. Each group member will be responsible for one Step 6

of the following body systems:

• orthopedist (skeletal system)

• ophthalmologist (vision system)

• cardiologist (heart and circulatory system)

• pulmonologist (respiratory system)

Direct the students to their computer stations in their groups. Give each Page 80

3

student one copy of Master 3.2 .

Step 7-w

Instruct students to click on “Activity 1: A Parent’s Dilemma” and then Page 80

on one of the medical specialties.

Step 8-w

Instruct students to review their medical specialty and record on their Page 80

handouts what they learn

Step 9-w

• about Patrick’s medical history,

• from Patrick’s physical exam, and

• about the possible causes of Patrick’s medical problems, based

4

on the information in the link to “Activity 3: Medical Reference

Manual.”

Instruct group members to share their findings and discuss whether

Page 81

Patrick’s medical problems are connected to each other and the

Step 10

evidence to support their conclusion.

Ask volunteers from each group to share their conclusions about

Page 81

whether Patrick’s medical problems are connected. Congratulate

Steps 11 and 12

students on their good work and agree that there might be a common

cause for Patrick’s medical problems that involves connective tissue.

5

Lesson 3

89

Activity 2: *Connective Tissue*

Estimated time: 25 minutes

Page and Step

Ask, “What is connective tissue?” Explain that it’s mostly made of

Page 82

proteins and forms tissues that help hold organs in place and that

Steps 1 and 2

connect muscles to bones and bones to bones.

Explain that students will use rubber bands to represent connective

Page 82

tissue and will compare the elasticity of two rubber bands.

Step 3

Display Master 3.7, read the instructions aloud, and make sure

Page 82

students understand how make the measurements.

Step 4

Arrange students in pairs. Give each pair

Page 82

• 1 meter stick

Step 5

• 1 rubber band from dish A (nonstretched)

• 1 paper clip

• 1 soda can containing about 2 ounces of water (or other

2–3-ounce weight)

Instruct pairs to record in their notebooks

Page 82

• the question they are investigating and

Step 6

• how far down the meter stick the rubber band stretched.

Collect the rubber bands. Give each pair a rubber band from dish B

Page 82

(previously stretched), and instruct pairs to make and record

Step 7

measurements as before.

Ask volunteers to report their conclusions. Did the two rubber bands

Page 83

perform differently and if so, how?

Step 8

Explain that the rubber band from dish A (nonstretched) represents

Page 83

normal connective tissue. Ask,

Steps 9 and 10

• “What do you think the rubber band from dish B represents?”

• “How might looser connective tissue affect the body?”

Explain that now they will investigate whether Patrick has a rare

Page 83

disease affecting his connective tissue.

Step 11

90

Rare Diseases and Scientific Inquiry

Activity 3: *A Common Thread*

Estimated time: 50 minutes

Page and Step

Remind students that Patrick's symptoms involve more than one body

Page 83

system and seem to have connective tissue in common. They will

Step 1

decide which, if any, rare disorder of connective tissue Patrick may

1

have.

Arrange the class in pairs. Give each pair a copy of Master 3.8.

Page 84

Step 2-w

Direct the pairs to their computers to click on "Activity 3: A Common

Page 84

Thread" and then "Activity 3: Medical Reference Manual."

Step 3-w

Ask volunteers to report their conclusions.

Page 84

Step 4

2

Agree that Marfan syndrome best explains for Patrick's symptoms. Ask,

Page 85

• "What is the cause of Marfan syndrome?"

Step 5

• "What evidence is there to suggest that Patrick may have Marfan

syndrome?"

Explain that students will look for evidence of Marfan syndrome in

Page 85

Patrick's family and record what they find in their notebooks. They

Step 6-w

should click on "Activity 3: A Common Thread" and then "Activity 3:

Patrick's Family Tree."

Remind students of the three major causes of disease. Ask,

Page 86

3

• "Did you find any evidence of Marfan syndrome in Patrick's

Step 7

family?"

• "Is there evidence to suggest that Patrick's symptoms may have a

different cause?”

Explain that an early diagnosis of Marfan syndrome allows people to

Page 86

take steps to protect their health. Ask, “In what ways might having

Step 8

Marfan syndrome affect your life?”

Explain that the lesson concludes with a brief video about young

Page 86

people who have Marfan syndrome. Instruct students to first write in

Step 9-w

their notebooks questions they would like to ask a person with Marfan

4

syndrome.

Instruct pairs to watch the video: click on “Activity 3: A Common

Page 87

Thread” and then “Activity 3: Patient Video.”

Step 10-w

Ask volunteers to describe their reactions to the video and how the

Page 87

video related to their questions.

Step 11-w

= Involves making a transparency.

= Involves using the Internet.

5

= Involves copying a master.

Lesson 3

91

Lesson 3 Organizer: Print Version

Activity 1: *A Parent's Dilemma*

Estimated time: 25 minutes

Page and Step

Explain that you will explore a case study about a child who has a rare Page 78

disease.

Steps 1

• Display Master 3.1.

and 2

• Ask volunteers to read paragraphs aloud to the class.

Ask, "Would you allow Patrick to try out for the basketball team?"

Page 78

Step 3

Explain that Patrick's parents looked into their family history and

Page 79

found relatives on his father's side who have had medical problems

Step 4

similar to Patrick's.

Explain that the family visited a medical geneticist to see if Patrick's Page 79

problems have a genetic cause.

Step 5

Explain that students will assume the roles of medical specialists and

Page 79

work in groups of four. Each group member will be responsible for

Step 6

one of the following body systems:

• orthopedist (skeletal system)

• ophthalmologist (vision system)

• cardiologist (heart and circulatory system)

• pulmonologist (respiratory system)

Give each student a copy of Master 3.2 .

Page 81

Step 7-p

Give each group of four one complete set of masters of doctors'

Page 81

reports: Masters 3.3, 3.4, 3.5, and 3.6

Step 8-p

Instruct students to review their medical specialty and the information Page 81

on the Medical Reference Manual section and record on Master 3.2

Step 9-p

what they learn

• about Patrick's medical history,

• from Patrick's physical exam, and

• about the possible causes of Patrick's medical problems, based

on the information Master 3.9.

Instruct group members to share their findings and discuss whether

Page 81

Patrick's medical problems are connected to each other and the

Step 10

evidence to support their conclusion.

Ask volunteers from each group to share their conclusions about

Page 81

whether Patrick’s medical problems are connected. Congratulate

Steps 11 and 12

students on their good work and agree that there might be a common

cause for Patrick’s medical problems that involves connective tissue.

92

Rare Diseases and Scientific Inquiry

Activity 2: *Connective Tissue*

Estimated time: 25 minutes

Page and Step

Ask, “What is connective tissue?” Explain that it’s mostly made of

Page 82

proteins and forms tissues that help hold organs in place and that

Steps 1 and 2

connect muscles to bones and bones to bones.

1

Explain that students will use rubber bands to represent connective

Page 82

tissue and will compare the elasticity of two rubber bands.

Step 3

Display Master 3.7, read the instructions aloud, and make sure

Page 82

students understand how make the measurements.

Step 4

Arrange students in pairs. Give each pair

• 1 meter stick

Step 5

• 1 rubber band from dish A (nonstretched)

• 1 paper clip

2

• 1 soda can containing about 2 ounces of water (or other

2–3-ounce weight)

Instruct pairs to record in their notebooks

Page 82

• the question they are investigating and

Step 6

• how far down the meter stick the rubber band stretched.

Collect the rubber bands. Give each pair a rubber band from dish B

Page 82

(previously stretched), and instruct pairs to make and record

Step 7

measurements as before.

Ask volunteers to report their conclusions. Did the two rubber bands

Page 83

perform differently and if so, how?

Step 8

3

Explain that the rubber band from dish A (nonstretched) represents

Page 83

normal connective tissue. Ask,

Steps 9 and 10

• “What do you think the rubber band from dish B represents?”

• “How might looser connective tissue affect the body?”

Explain that now they will investigate whether Patrick has a rare

Page 83

disease affecting his connective tissue.

Step 11

4

5

Lesson 3

93

Activity 3: *A Common Thread*

Estimated time: 50 minutes

Page and Step

Remind students that Patrick’s symptoms involve more than one body

Page 83

system and seem to have connective tissue in common. They will

Step 1

decide which, if any, rare disorder of connective tissue Patrick may

have.

Arrange the class in pairs. Give each pair a copy of Master 3.8 and Page 84

Master 3.9. Instruct students to use information on Master 3.9 to Steps 2-p

complete Master 3.8.

and 3-p

Ask volunteers to report their conclusions.

Page 84

Step 4

Agree that Marfan syndrome best explains for Patrick's symptoms. Ask,

Page 85

• "What is the cause of Marfan syndrome?"

Step 5

• "What evidence is there to suggest that Patrick may have Marfan syndrome?"

Explain that students will look on a handout for evidence of Marfan

Page 85

syndrome in Patrick's family and record in their notebooks what they

Step 6-p

find. Give each student pair a copy of Master 3.10.

Remind students of the three major causes of disease. Ask,

Page 86

• "Did you find any evidence of Marfan syndrome in Patrick's family?"

Step 7

• "Is there evidence to suggest that Patrick's symptoms may have a different cause?"

Explain that an early diagnosis of Marfan syndrome allows people to

Page 86

take steps to protect their health. Ask, "In what ways might having

Step 8

Marfan syndrome affect your life?"

Conclude by explaining that students will now consider how Marfan

Page 87

syndrome affects the lives of people who have it. Ask students to write Step 9-p in their notebooks

• one question they would like to ask a doctor about Marfan

syndrome and

• one way they think having Marfan syndrome might affect their lives.

Ask volunteers to report what they wrote.

Page 87

Step 10-p

Display Master 3.11, and give students time to read it. Ask,

Page 88

• “Were the questions and comments from the young people on

Steps11-p

the master similar to yours?”

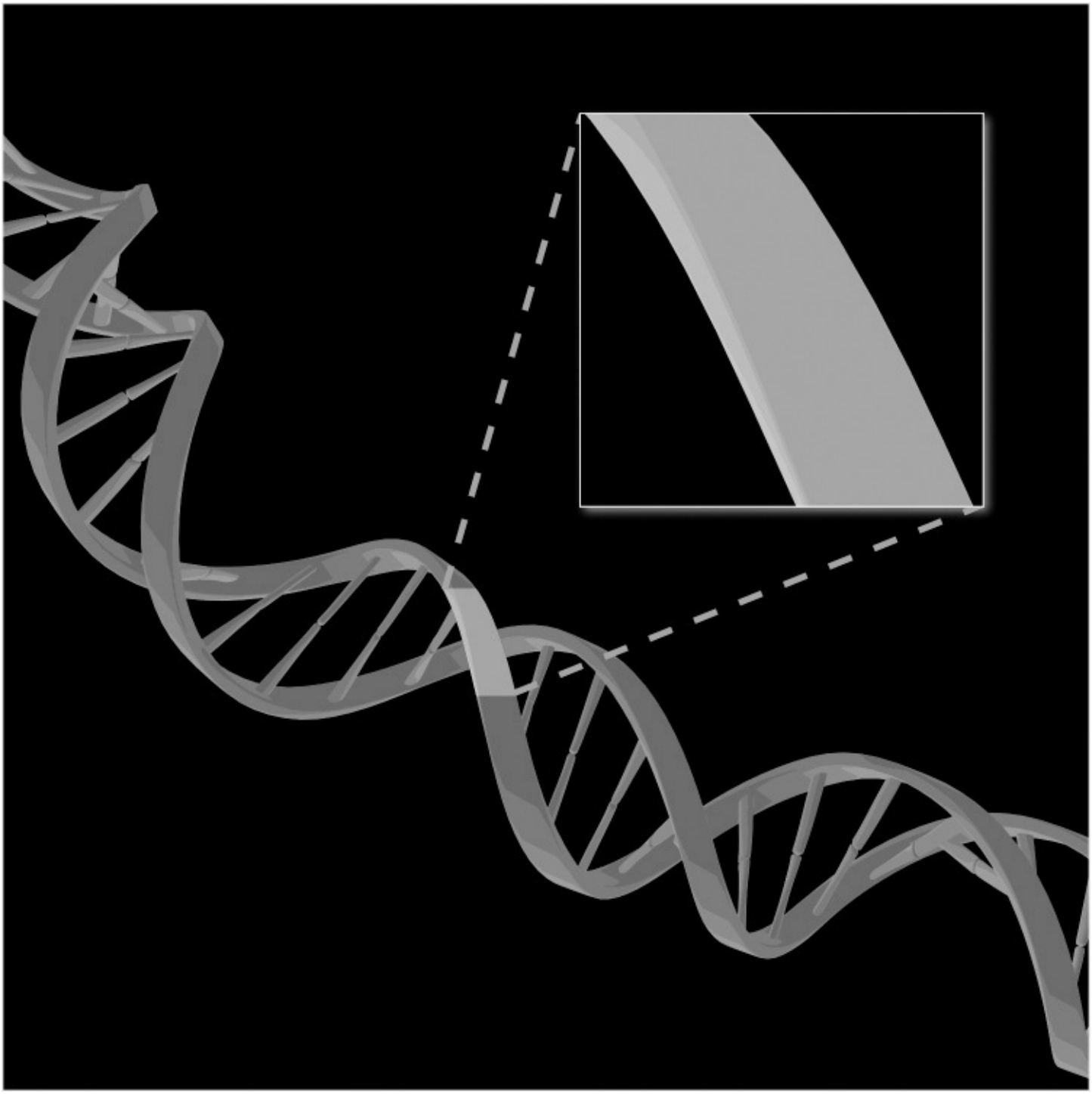
and 12-p

• “How would you want to be treated by your classmates if you

had Marfan syndrome?’

= Involves making a transparency.

= Involves copying a master.



Lesson 4

The Importance of Medical Research

1

2

Elaborate

At a Glance

Overview

Lesson 4 introduces the idea that medical research is important for the 3

treatment of a rare disease, childhood leukemia. In the first activity, students meet Jason and Kim, parents of a daughter named Hanna,

who has been diagnosed with childhood leukemia. Students perform a

simulated Web search to learn about the disease. They must sift through different Web hits to find relevant and accurate information about the

disease. In considering a genetic cause of the disease, students perform a karyotype analysis on each family member. In the second activity, students are introduced to treatments for leukemia. They design a clinical trial to guide the treatment of the disease. Finally, students watch a brief video (or, for classes using the print version, act out an interview) of a leukemia 4

survivor discussing what it's like to live with the disease.

Major Concepts

• Much medical information can be found on the Internet; however, this

information must be examined carefully to assess its relevance and

accuracy.

• Lack of appearance in a family history does not mean that a disease

doesn't have a genetic cause.

• Leukemia is a cancer of the white blood cells.

• Clinical trials have greatly improved the survival rates of children with leukemia.

5

95

Objectives

After completing this lesson, students will

• have used a simulated Web search to learn about the cause, symptoms,

and diagnosis of childhood leukemia;

• have performed a karyotype analysis to diagnose leukemia;

• have designed and tested a clinical trial for treating childhood leukemia; and

• have considered the challenges associated with living with leukemia.

Teacher Background

Consult the following sections in Information about Rare Diseases and Scientific Inquiry:

2.0 The Impact of Genomics on Rare Diseases (pages 24–27)

3.0 Rare Infectious Diseases (page 26)

4.0 Rare Diseases Caused by Environmental Toxins (pages 27–28)

5.3 Childhood Leukemia (pages 31–33)

In Advance

Web-Based Activities

Activity	Web Component?
1	Yes
2	Yes

Photocopies, Transparencies, Equipment, and Materials

Photocopies and Transparencies

Activity 1: An Unwelcome Diagnosis

For Classes Using the Web-Based Activity:

1 transparency of Master 4.1

1 copy of Masters 4.2 and 4.5 for each student

1 transparency and 1 copy for each student of Master 4.3

1 copy of Master 4.4 for each pair of students

For Classes Using the Print-Based Activity:

1 transparency of Master 4.1

1 copy of Masters 4.2, 4.5, 4.11, and 4.12 for each student

1 transparency and 1 copy for each student of Master 4.3

1 copy of Masters 4.4 and 4.10 for each pair of students

Continued

Photocopies and Transparencies

Activity 2: Clinical Trials

For Classes Using the Web-Based Activity

1 transparency of Master 4.6

1 copy of Masters 4.7, 4.8, and 4.9 for each pair of students

1

For Classes Using the Print-Based Activity:

1 transparency of Master 4.6

1 copy of Masters 4.7, 4.8, 4.9, 4.13, 4.14, 4.15, and 4.16 for each pair of students

2 copies of Master 4.17 for the class

Equipment and Materials

For Activities 1 and 2, Web-based versions, students will need computers with Internet access.

2

Preparation

Activities 1 and 2

For classes using the Web version, verify that the computer

lab is reserved for your class or that classroom computers

are set up for the activities.

Refer to Using the Web Site for details. Check that the Internet

connection is working properly.

3

Log on to the Web Portion of Student Activities section at

http://science.education.nih.gov/supplements/rarediseases/student

Select “Lesson 4: The Importance of Medical Research.”

Procedure

Note: This is an Elaborate lesson. It gives students an opportunity to take 4

what they have learned about rare diseases and scientific inquiry from

the previous lessons and apply it in a new setting. In the first activity, students place themselves in the role of a parent whose child has just

been diagnosed with childhood leukemia. They perform a simulated Web

search to learn about the disease. This activity is designed to help students hone their skills in evaluating information for relevance and accuracy.

The genetic link to the disease is made real to students by having them perform a simple karyotype analysis.

In the second activity, students exercise their understandings of scientific 5

inquiry in the context of clinical trials. Designing a fair test is a common Lesson 4

inquiry skill. We selected childhood leukemia because it is a rare disease that has a genetic cause. It's a serious disease, but, at the same time, it represents a real success story in the application of medical research to treatment.

The activity includes a graph that shows how survival rates for children with leukemia have dramatically improved over the past few decades. The lesson concludes with a video (or a role-play) of a young woman who has come through treatment for the disease and is now pursuing a medical

education. The inclusion of this story is designed to give students an

opportunity to empathize with someone who has had leukemia and also to

leave them with the vision of a positive outcome.

Activity 1: *An Unwelcome Diagnosis*

Estimated time: 100 minutes

1.

Begin the lesson by explaining that students will investigate a

case study involving a child with a rare disease.

This case study introduces the use of clinical trials to obtain

evidence about which treatment options are most effective. It's

not important that students understand the clinical trials process.

Instead, clinical trials provide a real-life example of how the practice of science (especially proper experimental design) can help improve

people's health.

2.

Display Master 4.1, *Doctor Visits*. Ask for volunteers to read aloud each section of text.

3.

Ask students how they would feel if they were Hanna's parent and received this disturbing news. Ask, "What would you do now that you have learned that your daughter has been diagnosed with leukemia?"

Content Standard C:

Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are obtained by infection by other organisms.

Students' responses will vary. Some students may suggest getting a second opinion. Others may suggest researching cancer treatment centers. Accept all answers and guide the discussion to the need to obtain more information.

4.

Explain that although the doctor described childhood leukemia and answered their questions during the office visit, Jason and Kim were so upset that they didn't take notes or remember much of what they were told. After returning

home with Hanna, they performed an Internet search on leukemia.

5.

Ask students,

• “If you were Hanna’s parent, what information would you want to have about the disease?”

• “Where could you find the information that you want?”

Make a list on the board of the types of information about leukemia the students request. Students may mention a variety of sources

1

for this information, including their doctors, books, television programs, the Internet, and, possibly, friends and family who have had to cope with the disease.

6.

Give each student one copy each of Master 4.2, *Internet Search Results*, and Master 4.3, *Evaluating Internet Search Results*. Instruct students to view the list of hits on Master 4.2 and follow the instructions on Master 4.3 to rank the hits from most helpful to least helpful.

2

This step is designed to challenge students to sort through information related to leukemia and decide

• which hits are most likely to contain the information they want

and

• which hits are likely to contain information that is accurate and

unbiased.

There is no single correct answer to ranking these eight hits. Rather,

you should see whether students can sift through the lists to identify

one or two of the best hits. Likewise, students should be able to

identify another couple of hits as clearly not helpful to providing the 3

information they want.

In this activity, students are ranking hits based on relevance and

accuracy. There are, however, other criteria that students should

use to assess the usefulness of Web sites. For example, the site

should present information that is up to date, and the information

should be as free of bias as possible, such as the bias associated with promoting a product or service.

Answer key for Web hits on Master 4.2, *Internet Search Results*

4

1. Federal Center for Cancer Research

Information about leukemia, its causes, symptoms, diagnosis,

and treatment …

Hit 1 is from a fictional U.S. government research organization,

the Federal Center for Cancer Research. The Federal government,

however, does support medical research, primarily through the

5

Lesson 4

99

National Institutes of Health (NIH). For example, the Office of

Rare Diseases Research (http://rarediseases.info.nih.gov/) and the

National Cancer Institute (http://www.cancer.gov/) are parts of

NIH and provide accurate medical information resources for the

general public. Such government sites post information that has

been reviewed by experts and is labeled "no commercial bias,"

which means that the information presented hasn't been selected to

promote the use of any particular product or service. Such sites are a logical place to begin to learn about a rare disease.

2. My Leukemia Blog

Living with Cancer: Reflections and remembrances of a cancer

survivor …

Personal blogs can provide a window into the life of someone

who has a rare disease. The person may or may not choose to

include medical information as part of the blog. Furthermore, any

medical information on the blog may reflect a possibly incomplete

understanding by the author. Although such blogs can be helpful

resources, they are not the best place to begin to learn about a rare disease.

3. The Cancer Research Center at Lincoln State University

Breast cancer, Prostate cancer, Leukemia, Lymphoma, …

Research centers based at universities often provide medical

information to the public. The information is reviewed by experts

for accuracy. Often, the posted information is tied to the research interests of individual scientists and may be too specific to be a

starting point for searching about a rare disease.

4. Information about Leukemia from the American Blood

Cancer Society

Cells of the blood, Stem cells and leukemia, White blood cells

and bacteria …

Hit 4 is from a patient support group. Although the American Blood

Cancer Foundation is fictional, a large number of patient-support

organizations exist to promote medical research and support for

people with rare diseases. In the case of leukemia, the Leukemia

and Lymphoma Society (http://www.leukemia.org/hm_lls) is a very

useful resource that provides reliable disease information as well as a variety of patient services. Such sites are a logical place to begin to learn about a rare disease.

100

Rare Diseases and Scientific Inquiry

5. Leukemia—Medhealthopedia: The Do-It-Yourself Encyclopedia

Leukemia is a form of cancer that is …

Medhealthopedia is a fictional Web site that provides medical

information to the public in a manner similar to Wikipedia. On

such a site, the information posted is written collaboratively by

users of the site. The information is often reliable, but there is

1

no assurance that experts have reviewed it or that it is free of

commercial bias.

6. Cancer drugs for less! Leukemia

Order drugs from overseas to treat leukemia and save!

Hit 6 is included as a reminder that some information about disease on the Internet is more concerned with making money for someone

than with providing objective medical information.

2

7. Fed approves new drug to treat leukemia

Medical Business Weekly **(Washington, DC)—The Food and**

Drug Administration today approved Hamilton Pharmaceutical's

As students report

drug Arresta for the treatment of leukemia …

how they ranked

the hits from the

Hit 7 is from a business publication. Although the information is

likely to be accurate, it only describes one specific development in **simulated Web**

the field of leukemia research and is not a good place to begin to

search, you have

learn about the disease.

an opportunity to

assess how well they

8. Leukemia: Definition from Medical Jargon.com

3

use their critical-

Leukemia—A form of cancer involving the white blood cells.

thinking skills to

White …

evaluate information

Hit 8 comes from a medical dictionary and only provides a brief

for its relevance and

definition of the disease.

accuracy.

7.

Display Master 4.3. Ask for volunteers to report how they

ranked the Web hits.

Students' responses will vary. Allow several volunteers to report

their rankings with explanations of their reasoning. Remember

4

that the precise ranking of the Web sites is not important. Ideally,

students will recognize that Hits 1 and 4 are the best places to begin

to learn about leukemia. Hits 2, 3, and 5 can also be useful, but the

information may not be as relevant or as accurate as that from Hits

1 and 4. Some students may reason that Hit 8, which provides a

definition, is a good place to start. Hits 1 and 4, however, will also

provide a definition along with a lot of other useful information.

Hits 6 and 7 are clearly not very useful.

5

Lesson 4

101

In classrooms using the Web version of the activity:

8-w. Arrange the students in pairs. Give each pair

one copy of Master 4.4, *Summarizing Information*

***about Leukemia*. Explain that student pairs will go to their computers and access information about leukemia from Hits**

1 and 4 from the Internet search. Pairs should summarize on

Master 4.4 the information from both Web hits.

Computers should be at this URL:

http://science.education.nih.gov/supplements/rarediseases/student

This is a menu page that contains a link for this activity.

9-w. Direct the pairs to their computer stations and instruct them

to click on "Lesson 4: The Importance of Medical Research,"

then "Activity 1: An Unwelcome Diagnosis," and then

"Activity 1: Simulated Web Search."

"Activity 1: Simulated Web Search" contains information found

on Hits 1 and 4, which were listed on Master 4.2. These are the

hits judged to be the best places to begin a search for information

about leukemia.

In classrooms using the print version of the activity:

8-p. Arrange the students into pairs. Give each pair one

copy each of Master 4.4, *Summarizing Information about Leukemia,* and Master 4.10, *Information about Leukemia*.

9-p. Explain that student pairs should look at the information on Master 4.10 and summarize it on Master 4.4.

Master 4.10 contains information found on Hits 1 and 4, which were listed on Master 4.2. These are the hits judged to be the best places to begin a search for information about leukemia.

10. After students have completed the tasks, reconvene the class. Ask whether students have any questions about the information they found from the Internet search.

Clarify any confusion and misunderstandings. If students ask about the case of leukemia, ask them to hold on because the class is about to consider that question.

11. Ask students to recall the three causes of disease.

If necessary, ask guiding questions to bring out the three causes: infectious agents, heredity (genetics), and exposure to environmental toxins.

12. Ask, “What types of information would you want to have to

1

decide which of the three causes of disease applies to leukemia?”

Students may suggest information about a family history of leukemia and about exposure to toxic substances or pathogens.

13. Explain that the parents, Jason and Kim, have two children:

Hanna, who was just diagnosed with leukemia, and her older

brother, Rick, who is healthy. There is no history of leukemia in the family. Ask, “Does this rule out genetics as the cause of leukemia?”

2

Most students will conclude that it does. At this time, accept all

answers.

14. Ask, “What about environmental exposure or infections?”

Some students may remark that Hanna shows signs of infection.

Point out that the rest of the family is infection free. Also, if Hanna had been exposed to a dangerous substance in her environment, we

might also expect that the rest of the family had also been exposed,

but they remain healthy.

3

15. Acknowledge that so far, there isn’t good evidence to suggest

a cause for Hanna’s leukemia. Return to the idea of genetics.

Ask students to recall Information about Leukemia from the

American Blood Cancer Society. Ask, “What happened to a stem

cell that led to leukemia?”

Students should recall that a single stem cell acquired mutations and

began to grow out of control, producing large numbers of unhealthy

white blood cells.

Note: Since your students have a limited understanding of genetics, they 4

may believe that mutations are something that only took place many years ago. You may need to stress the idea that mutations are happening now

and can cause disease. Explain that cells have mechanisms that detect and correct mutations, but in rare cases, these mechanisms fail.

16. Explain that although people sometimes inherit mutations

from their parents, new mutations happen as well. Mutations

in DNA can occur from exposure to sunlight or to substances

in the environment, or sometimes they occur just because the

cell makes a DNA-copying mistake during cell division that is

5

Lesson 4

103

not corrected. If mutations occur in genes associated with cell

growth, cancer can result.

This is an opportunity to have students think back to Lesson 3,

which dealt with Marfan syndrome and a genetic mutation. Both

Content Standard C:

diseases have a genetic association. If you think it would be helpful

Hereditary information

ask, “How are they similar? How are they different?”

is contained in

genes, located in

17. Explain that in some genetic disorders, the effects of mutations the chromosomes

can be so large that they change the number and appearance of

the chromosomes. Scientists call a photograph of chromosomes

of each cell. Each

under a microscope a karyotype. Give each student one copy of

gene carries a single

Master 4.5, *Karyotype*.

unit of information.

An inherited trait of

You may need to help students understand the idea of a

an individual can be

chromosome. You can explain that the DNA in each cell is arranged

determined by one

in packages called chromosomes. Each different chromosome

contains a single molecule of DNA.

or by many genes,

and a single gene can

18. Explain that students first need to see what a normal karyotype influence more than

looks like before they can understand what a karyotype with

one trait. A human

a large mutation looks like. Instruct students to read the

cell contains many

information on Master 4.5 and answer the question at the bottom.

thousands of different

While students are reading the handout, circulate and answer any

genes.

questions they may have. For example, you may need to explain

that the karyotype is made by squashing cells and taking a picture

of the chromosomes through a microscope. Then, the photograph

is cut up, and the chromosomes are rearranged in pairs to make it easier to see abnormal patterns.

Students may observe differences in the shapes of chromosome pairs in the karyotypes, but these shapes result from how the chromosomes were positioned when the cells were squashed and do not represent genetic mutations. A normal karyotype has 22 pairs of numbered chromosomes as well as a pair of sex chromosomes (X and Y). A male has one X chromosome and one Y chromosome. A female has two X chromosomes and no Y chromosome. The individual whose karyotype is depicted here is male because both an X and a Y chromosome are present.

19. Explain that in the case of leukemia, the karyotype would be expected to show three, instead of the normal two, copies of one or more of the numbered (nonsex) chromosomes.

Students should pay attention to the numbers of each chromosome. The presence of three copies of a chromosome is abnormal and helps diagnose leukemia.

(For print version, skip to Step 20-p on page 106.)

In classrooms using the Web version of the activity:

20-w. Direct student pairs back to their computers.

Explain that they will first observe karyotypes prepared from

blood samples taken from each of Hanna's family members.

1

Instruct students to predict whether the karyotype for each

family member will appear normal or abnormal.

Students should make predictions for Jason and Kim (Hanna's

parents), Hanna, and Rick (Hanna's brother). They should

recall that Hanna is the only family member with leukemia and,

therefore, only her karyotype should appear abnormal.

Note: To reinforce the role of the sex chromosomes, you may want to ask students to identify the sex of each family member from the person's 2

karyotype.

21-w. Instruct student pairs to click on "Lesson 4: The Importance

of Medical Research," then "Activity 1: An Unwelcome

Diagnosis," and then "Activity 1: Karyotypes." Students will

see a karyotype from the parents, Jason and Kim, as well as

from Hanna and her brother, Rick. Students should record

in their notebooks whether each karyotype is normal or

abnormal and whether the evidence supports their predictions.

22-w. Explain that the link labeled “View All of Hanna’s Karyotypes”

3

will display three karyotypes from Hanna. The first karyotype

was taken from her blood sample as before, the second was

from her cheek cells, and the third, from her hair follicles. As

before, instruct student to predict whether each karyotype will

be normal or abnormal.

Students should predict that the karyotype from Hanna’s blood

sample will appear abnormal, as it was earlier. Some students may

Evaluating karyotypes

not realize that the abnormal chromosomes are limited to the

taken from different

white blood cells. They will see, however, that the karyotypes from

body tissues allows

4

Hanna’s cheek cells and hair follicles are normal.

you to assess how

23-w. Ask, “How can you account for the appearance of the

well students

karyotypes taken from these three different tissues?”

understand the

basic idea of cancer,

Guide the discussion to bring out that the leukemia started with

namely, that the

a single stem cell in the bone marrow that went on to produce

disease begins with

a large population of unhealthy white blood cells, each with an

mutations in a single

abnormal karyotype. In contrast, the cheek cells and hair follicle

cells are unaffected by leukemia and show normal karyotypes.

cell in one part of the

body.

5

End of Web-based activity.

Lesson 4

105

In classrooms using the print version of the activity:

20-p. Explain that students will look at karyotypes

prepared from blood samples taken from each of

Hanna's family members. Ask students to predict whether

the karyotype for each family member will appear normal or

abnormal and to record in their notebooks whether the evidence

supports their predictions.

Students should make predictions for Jason and Kim (Hanna's

parents), Hanna, and Rick (Hanna's brother). They should recall

that Hanna is the only family member with leukemia and, therefore,

only her karyotype should appear abnormal.

Note: To reinforce the role of the sex chromosomes, you may want to ask students to identify the sex of each family from the person's

karyotype.

21-p. Give each student pair one copy of Master 4.11, *Family Karyotypes*. Instruct students to examine the karyotypes and note whether their predictions were confirmed.

If any pairs struggle with this task, remind them that each numbered chromosome should exist as a pair. If a third copy of any chromosome is present, it represents a mutation and helps diagnose leukemia.

22a-p. Explain that students will now look at three different karyotypes, all from Hanna. One karyotype is taken from her blood as before, one is from her cheek cells, and another, from her hair follicles. As before, instruct students to predict whether each karyotype will be normal or abnormal and to record their predictions in their notebooks.

Students should predict that the karyotype from Hanna's blood sample will appear abnormal, as it was earlier. They likely will predict that the karyotpes from her cheek cells and hair follicles will also be abnormal.

22b-p. Give each student pair one copy of Master 4.12, *Hanna's Karyotypes*. Instruct students to examine the karyotypes and note whether their predictions were confirmed.

Some students may not realize that the abnormal chromosomes are limited to the white blood cells.

23-p. Ask, "How can you account for the appearance of the karyotypes taken from these three different tissues?"

Guide the discussion to bring out that the leukemia started with a single stem cell in the bone marrow that went on to produce a large population of unhealthy white blood cells, each with an abnormal karyotype. In contrast, the cheek cells and hair follicle cells are unaffected by leukemia and show normal karyotypes.

Evaluating karyotypes

taken from different

1

Activity 2: *Clinical Trials*

body tissues allows

Estimated time: 50 minutes

you to assess how

well students

1.

Display Master 4.6, *Another Doctor Visit.* Ask for volunteers to understand the read aloud each section of text.

basic idea of cancer, namely, that the

Ethical concerns cause the design of clinical trials to sometimes differ from that of animal studies. If a treatment for a disease is

disease begins with

known to have some benefit, then it is unethical to replace that

mutations in a single

treatment with another one whose value is unknown.

cell in one part of the

2

body.

2.

Explain that doctors often compare the effectiveness of cancer

treatments by looking at the percentage of patients who are still

alive five years after treatment. This helps explain why a series

of clinical trials takes so long to improve survival rates.

3.

Explain that students will now go back in time to the year 1970

and play the roles of doctors trying to improve the survival rates

of children with leukemia. Still working in their pairs, students

will have the opportunity to design, carry out, and assess the

effectiveness of a clinical trial.

3

Over the past 50 years, steady progress has been made in improving

the survival rates for children with leukemia. We chose the period

around 1970 for this activity because one specific treatment (of the

central nervous system, or CNS) led to a very significant gain in

survival rate. Students will see the value of clinical trials when they examine survival rates over time on Master 4.9, *Survival Rates for*

Children with Leukemia.

4.

Give each student pair one copy of Master 4.7, *Treating*

4

***Leukemia*. This handout describes the treatment options students can include in the clinical trial:**

• Three different drugs (A, B, and C) are available. Each drug has been shown to improve the survival rates of patients taking its standard dose. Research also indicates that the best results are achieved when the three drugs are used in combination.

• For each drug, three different doses are available:

standard dose

increased dose

decreased dose

5

• The CNS treatment follows the drug treatment described above. It involves irradiating the patient's head with X-rays while drug C (methotrexate) is injected into the spinal fluid. This approach is intended to kill cancer cells that may have escaped the effects of the earlier drug treatment and are lurking in the CNS.

(For print version, skip to Step 5-p on page 110.)

In classrooms using the Web version of the activity:

5-w. Explain that student pairs will use the computer to design and carry out a clinical trial. Before moving to the computers, make the students aware of the following:

• The standard therapy (control) for treating leukemia is a combination therapy using the standard doses of drugs A, B, and C.

• Pairs select the characteristics (drug doses and use or nonuse of the CNS treatment) of the therapy they want to compare with the standard treatment.

• After students select the treatment, they submit it, and the trial design is analyzed by the computer software. If the

trial design is appropriate, then the trial is approved, and

the pair can run the trial and learn the results. If a flaw is

found in the trial design, then students have an opportunity

to correct it and go on to run the trial.

In designing the clinical trial, students may be tempted to use

more of everything. Remind students that each treatment is

associated with side effects that are sometimes very harmful.

Although proper trial design involves a number of aspects, we

Content Standard A:

are focusing on just one—control of variables. Students should

Students should

understand that a proper design involves changing just one

develop general

variable while keeping other variables constant relative to the

abilities, such

comparison (control) group of patients. Students must remember

as systematic

that their proposed treatment will be compared with the standard

observation,

treatment (using drugs A, B, and C at their standard doses *without*

the CNS treatment).

making accurate

• Pairs that decide to use the CNS treatment must keep drugs A,

measurements,

B, and C at the standard doses.

and identifying and

• Pairs that decide not to use the CNS treatment can change

controlling variables.

the dose of *one* of the three drugs while keeping the other two drugs at the standard doses.

Note: After students submit a design that is approved, run the trial, and get the results, they can try other designs by simply changing their selections and resubmitting a new design.

108

Rare Diseases and Scientific Inquiry

6-w. Give one copy of Master 4.8, *Designing a Clinical Trial*, to each student pair. Instruct students to use this handout to record

the treatment options they select as well as the trial results

(survival rate data) and conclusions they draw from the data.

As students design

7-w. Explain that in a clinical trial such as this, the experimental and test the clinical

1

treatment is compared with the standard treatment. Ask,

trials, you have

“Should the clinical trial also include a group that receives no

an opportunity to

treatment?”

assess how well

Students' responses may vary. Students who think just in terms they understand the

of good experimental design may respond that including a no-concept of controlling

treatment group would better indicate how well the experimental variables.

treatment performs. Others may point out that it would not be fair to withhold treatment from a group of patients. In fact, the latter view prevails. For ethical reasons, a no-treatment group would not be included in the design of such a clinical trial.

2

8-w. Direct the students back to their computers and instruct them to click on "Lesson 4: The Importance of Medical Research," then "Activity 2: Clinical Trials."

• Students will see the treatment options and boxes where they can make their selections.

• After selecting the treatment options, students click the "Submit" button to have the trial design analyzed.

If the design is judged to be appropriate, then a letter will appear that instructs the students to proceed with the clinical

3

trial. A "Run treatment" button appears. When it is clicked, the trial results are shown on a graph of survival over time.

If the design is judged to not be appropriate, then a letter will appear that reminds the students to change just one

variable at a time. A “Try again” button appears. When it is clicked, the treatment options reappear, and the pair has an opportunity to redesign the trial.

When doctors carry out clinical trials, they first submit the

4

study design to a committee called an institutional review board (IRB). The IRB members discuss the proposed study and decide whether it is designed correctly and meets the ethical standards for experimenting with humans.

9-w. Give pairs about 15 minutes to run the clinical trial, record the results, and draw a conclusion.

The results of each clinical trial are presented as a graph with the percentage of surviving patients on the *y*-axis and time

5

Lesson 4

(in years) on the *x*-axis. One line on the graph corresponds to the standard treatment (control), and a second line corresponds to the experimental treatment group. On the basis of these data, students should recommend either the standard treatment or the experimental treatment. Students should provide evidence that

supports their recommendation.

Continue with Step 10 on page 112.

In classrooms using the print version of the activity:

5-p. Explain that pairs will design and carry out a clinical trial. Make the students aware of the following:

• The standard therapy (control) for treating leukemia is a combination therapy using the standard doses of drugs A, B, and C.

• Student pairs select the characteristics (drug doses and use or nonuse of the CNS treatment) of the therapy they want to compare with the standard treatment.

• After students select the treatment, they submit it to you for analysis. If the trial design is appropriate, then approve the trial and give the pair the results. If you find a flaw in the trial design, then give students an opportunity to correct it before proceeding.

In designing the clinical trial, students may be tempted to use more of everything. Remind them that each treatment is associated with side effects that are sometimes very harmful.

Although proper trial design involves a number of aspects, we are focusing on just one—control of variables. Students should

Content Standard A:

understand that a proper design involves changing just one variable

Students should

while keeping other variables constant relative to the comparison

develop general

(control) group of patients. Students must remember that their

abilities, such

proposed treatment will be compared with the standard treatment

(using drugs A, B, and C at their standard doses *without* the CNS

as systematic

treatment).

observation,

• Student pairs that decide to use the CNS treatment must keep

making accurate

drugs A, B, and C at the standard doses.

measurements,

• Pairs that decide not to use the CNS treatment can change the

and identifying and

dose of *one* of the three drugs while keeping the other two drugs controlling variables.

at the standard doses.

6-p. Explain that in a clinical trial such as this, the experimental treatment is compared with the standard treatment. Ask,

“Should the clinical trial also include a group that receives no

treatment?”

Students' responses may vary. Students who think just in terms of good experimental design may respond that including a no-treatment group would better indicate how well the experimental treatment performs. Others may point out that it would not be fair to withhold treatment from a group of patients. In fact, the latter view prevails. For ethical reasons, a no-treatment group would not be included in the design of such a clinical trial.

As students design and test their clinical trials, you have an opportunity to assess how well they understand the concept of controlling variables.

• use Master 4.8 to record the treatment options they select and

• submit their design to you for evaluation.

7a-p. Give each student pair one copy of Master 4.8, *Designing a Clinical Trial*. Instruct students to

1

Students will need only about five minutes to discuss the trial

design and make their selections.

7b-p. Explain that a clinical trial must be approved by an

2

institutional review board (IRB) before it is carried out. The

IRB determines whether the trial is both ethical and properly

designed. As each pair submits a clinical trial design, check

that only one variable is being tested.

A correct design will vary the dose of a single drug or will keep

all three drugs at the standard doses and test the effect of the CNS

treatment.

8-p. After each pair has submitted a properly designed clinical trial, explain that the trial was performed, and you have the results.

3

Give each student pair the appropriate handout:

• Pairs that chose to test the dose of drug A receive Master

4.13, *Changing the Dose of Drug A*.

• Pairs that chose to test the dose of drug B receive Master

4.14, *Changing the Dose of Drug B*.

• Pairs that chose to test the dose of drug C receive Master

4.15, *Changing the Dose of Drug C*.

• Pairs that chose to test the effect of the CNS treatment receive

Master 4.16, *Central Nervous System Treatment*.

4

The results of each clinical trial are presented as a graph with

the percentage of surviving patients on the *y*-axis and time (in years) on the *x*-axis. One line on the

graph corresponds to the

standard treatment (control), and a second line corresponds to the

experimental treatment group.

9-p. Instruct student pairs to summarize the data on Master 4.8

in the box labeled “Clinical Trial Results.” On the basis of the

results, students should recommend treating Hanna with the

standard treatment or the experimental treatment. They should

state their recommendation and explain their reasoning in the

box labeled “Conclusion from the Clinical Trial.”

If pairs chose to vary the dose of one of the three drugs, the results

will show little difference between the standard treatment (control)

and the experimental treatment (altered dose). Students should look

at the graph on the handout and estimate the five-year survival rates

for the control and experimental groups of patients.

If pairs chose to test the effect of the CNS treatment, they will

see a significant difference between the control and experimental

groups.

10. Reconvene the class and ask for volunteers to report which

treatment they compared with the standard treatment and to

indicate whether their treatment was better or worse than the

standard treatment.

Keep track of and display results as they are reported. Changing the

dose of one of the three drugs used to treat leukemia produces only modest differences when compared with the standard treatment. In contrast, the CNS treatment produces much greater gains in the survival rate.

11. Give each student one copy of Master 4.9, *Survival Rates for Children with Leukemia.* Explain that the doctor showed this graph to Jason and Kim to help them understand how effective clinical trials have been in improving the survival rates of children with leukemia.

Master 4.9 is a graph depicting how survival rates of children with leukemia have improved over the past 50 years. Ask questions to gauge students' understanding of the graph. The main point of the graph is that studies carried out in the past showed five-year survival rates that were lower than studies conducted more recently. This means that the results of earlier clinical trials have been successfully used to improve the survival rates of patients.

12. Ask students to think back to the Web search they performed during the first part of the lesson. Remind them that they evaluated the results to find the hits most likely to give them relevant and accurate information about childhood leukemia. Ask, "What other results from the Web search could give us a different type of perspective about childhood leukemia?"

Some students will likely suggest that the leukemia blog would provide a patient's perspective on the disease.

(For print version, skip to Step 13-p on page 114.)

In classrooms using the Web version of the activity:

13-w. Acknowledge that blogs and videos created by cancer survivors can offer an important perspective on what it's like to live and cope with leukemia. Conclude the lesson

1

by explaining that students will watch a brief video called "Hailey's Story." It was made by a young woman who was diagnosed with childhood leukemia when she was in middle school. Before directing the pairs to their computers, instruct students to write in their notebooks some questions that they would like to ask Hailey about her experiences.

14-w. Direct the students to their computers and instruct them to click on "Lesson 4: The Importance of Medical Research," and then "Activity 2: Hailey's Story."

2

The video is brief, five minutes long. If you have the ability to project the computer image, it may be simpler to watch the video

as a group.

15-w. After student pairs have watched the video, reconvene the

class. Ask for volunteers to describe their reactions to the

video and how it addressed (or did not address) the questions

they wrote in their notebooks.

During the video, Hailey mentions that the Leukemia and

3

Lymphoma Society presented her with the Spirit of Tom Landry

Award. Tom Landry was the coach of the Dallas Cowboys football

team. He died from leukemia in 2000.

Hailey mentions that she wants to fight cancer by becoming a

pediatric oncologist. You may need to explain to the class that a

pediatric oncologist is a doctor who treats cancer in children.

The video will not answer all of the students' questions. Suggest that

they perform a Web search to access information from foundations

4

and patient support groups that can answer their questions.

Note: In the video, Hailey mentions that more than 12,000 children and teenagers will be diagnosed with cancer this year and that about 1 in

3 will die from it. Students may find this confusing since the graph on Master 4.9 shows a current survival rate of about 90 percent. Explain

that the lower survival rate Hailey mentioned comes from combining

the survival rates from all forms of cancer and not just leukemia, which responds better to treatment.

End of Web-based activity.

5

Lesson 4

In classrooms using the print version of the activity:

13-p. Acknowledge that blogs and videos created by cancer survivors can offer an important perspective on what it's like to live and cope with the illness. Conclude the lesson by explaining that the class will conduct a brief interview with a high school senior who was diagnosed with leukemia when she was in eighth grade.

Note: During the interview, Hailey mentions missing a year of school. As she explains in her video, she missed school while undergoing chemotherapy and kept up with her studies with the help of a tutor.

14-p. Explain that the interview is based on the words of an actual cancer survivor named Hailey. Ask for one volunteer to ask the questions and another to play Hailey and read her responses. Students may become interested in Hailey's story and want to see her video. If so, give them the link to the Web site.

15-p. Give the student interviewer and the student playing Hailey each a copy of Master 4.17, *Interview with Hailey*. Instruct the two student actors to come to the front of the room and conduct the interview.

During the interview, Hailey mentions that the Leukemia and Lymphoma Society presented her with the Spirit of Tom Landry Award. Tom Landry was the coach of the Dallas Cowboys football team. He died from leukemia in 2000.

Hailey mentions that she wants to fight cancer by becoming a pediatric oncologist. You may need to explain to the class that a

pediatric oncologist is a doctor who treats cancer in children.

16-p. After the student actors return to their seats, ask for volunteers to describe their reactions to the interview.

Students may still have questions about leukemia. Suggest that they

perform a Web search to access information from foundations and

patient support groups that can answer their questions.

114

Rare Diseases and Scientific Inquiry

Lesson 4 Organizer: Web Version

Activity 1: *An Unwelcome Diagnosis*

1

Estimated time: 100 minutes

Page and Step

Explain that students will explore a case study of a child who has Page 98

a rare disease.

Steps 1

• Display Master 4.1.

and 2

• Ask volunteers to read paragraphs aloud to the class.

Ask, “What would you do now that you have learned that your

Page 98

daughter has been diagnosed with leukemia?”

Step 3

Explain that after the upsetting visit to the doctor, Jason and Kim

Page 98

performed an Internet search on leukemia.

Step 4

2

Ask students:

Page 99

• “If you were Hanna’s parent, what information would you

Step 5

want to have about the disease?”

• “Where could you find that information?”

Give each student a copy of Masters 4.2 and 4.3. Instruct Page 99

students to rank on Master 4.3 the usefulness of the hits listed

Step 6

on Master 4.2.

Display Master 4.3. Ask volunteers to report how they ranked Page 101

3

the Web hits.

Step 7

Arrange the class in pairs. Give each pair a copy of Master

Page 102

4.4. Explain that students will now access information about

Step 8-w

leukemia from Hits 1 and 4 from the Internet search and

summarize on Master 4.4 what they learn.

Instruct students to click on “Activity 1: An Unwelcome

Page 102

Diagnosis” and then on “Activity 1: Simulated Web Search.”

Step 9-w

Reconvene the class and ask whether students have questions

Page 102

4

about the information from the Web hits.

Step 10

Remind students about the three general causes of disease.

Page 103

Ask, “What types of information would you want to have in

Steps 11 and 12

order to decide which of the three causes of disease applies to

leukemia?”

5

Lesson 4

115

Explain that Jason and Kim have two children: Hanna, who has

Page 103

leukemia, and Rick, her healthy older brother. Also, say that

Steps 13 and 14

there’s no history of leukemia in the family. Ask,

• “Does this rule out genetics as the cause of leukemia?”

• “What about environmental exposure or infections?”

Acknowledge that so far, there isn’t good evidence to suggest

Page 103

a cause for Hanna’s leukemia. Remind students about the

Step 15

Animation about Leukemia. Ask, “What happened to a stem cell

that led to leukemia?”

Explain that new mutations happen from exposure to sunlight

Page 103

and substances in the environment or from an uncorrected

Step 16

DNA-copying mistake. Mutations in genes associated with cell

growth can lead to cancer.

Explain that mutations can affect the number and appearance

Page 104

of chromosomes and that a photograph of chromosomes under

Step 17

a microscope is a karyotype. Give each student a copy of

Master 4.5.

Instruct students to read Master 4.5 and answer the question

Page 104

at the bottom. Explain that in leukemia, we expect a karyotype

Steps 18 and 19

to show three, not two, copies of one or more of the numbered

(nonsex) chromosomes.

Direct student pairs back to the computers. Explain that they will

Page 105

view karyotypes from Hanna and her immediate family. Instruct

Step 20-w

students to predict whether each karyotype will appear normal

or abnormal.

Instruct students to click on “Activity 1: An Unwelcome

Page 105

Diagnosis” and then on “Activity 1: Karyotypes.”

Step 21-w

Explain that the link labeled “View All of Hanna’s Karyotypes”

Page 105

displays karyotypes from three cell types: blood, cheek, and hair

Step 22-w

follicles. Ask pairs to predict how each karyotype will appear and

to record their predictions in their notebooks.

Ask, “How can you account for the appearance of the karyotypes

Page 105

taken from these three different tissues?”

Step 23-w

116

Rare Diseases and Scientific Inquiry

Activity 2: *Clinical Trials*

Estimated time: 50 minutes

Page and Step

Display Master 4.6. Ask volunteers to read it aloud.

Page 107

Step 1

1

Explain that doctors compare the effectiveness of cancer

Page 107

treatments by looking at the percentages of patients still alive

Step 2

after five years.

Explain that students will go back to the year 1970 and assume

Page 107

the roles of doctors trying to improve the survival rates of

Step 3

children with leukemia by conducting a clinical trial.

Give each student pair a copy of Master 4.7. Explain that it

Page 107

describes the treatment options they can include in their clinical

Step 4

trial.

2

Explain that student pairs will use computers to design and carry Page 108

out their clinical trial. Explain that

Step 5-w

• The standard therapy is a combination of the standard

doses of drugs A, B, and C.

• Pairs will select drug doses and the use or nonuse of the

central nervous system treatment.

• They will submit the design for approval. Once approved, the

trial will be carried out and students will learn the results.

Give each pair a copy of Master 4.8 . Instruct students to record Page 109

3

their treatment options, trial results, and conclusions on it.

Step 6-w

Explain that in a clinical trial such as this, the experimental

Page 109

treatment is compared with the standard treatment. Ask, “Should Step 7-w the clinical trial also include a group that receives no treatment?”

Direct students to their computers and instruct them to click

Page 109

on “Activity 2: Clinical Trials.” Student pairs should select the

Steps 8-w

treatments and then click “Submit.”

and 9-w

• If approved, students can click “Run treatment” and learn

4

the results.

• If rejected, students can redesign the trial.

• After recording the trial results, students should make and record their conclusions.

Reconvene the class. Ask volunteers to report the designs and

Page 112

results of the trials and how their treatment compared with the

Step 10

standard treatment.

5

Lesson 4

117

Give each student a copy of Master 4.9 and explain that this is

Page 112

what the doctor showed Hanna’s parents to help them see how

Step 11

effective clinical trials have been in improving survival rates of children with leukemia.

Remind students of the Web search they performed about

Page 112

leukemia. Ask, “What other results from the Web search

Step 12

could provide us with a different perspective about childhood

leukemia?”

Conclude the lesson by explaining that students will watch

Page 113

a brief video created by a young woman who is a leukemia

Step 13-w

survivor. Ask students to write in their notebooks some

questions they would like to ask the young woman about her

experiences.

Instruct students to click on “Activity 2: Hailey’s Story” and watch Page 113

the video.

Step 14-w

Reconvene the class and ask volunteers to describe their

Page 113

reactions to the video and to explain how it addressed (or did

Step 15-w

not address) the questions they wrote in their notebooks.

= Involves making a transparency.

= Involves copying a master.

= Involves using the Internet.

Lesson 4 Organizer: Print Version

Activity 1: *An Unwelcome Diagnosis*

Estimated time: 100 minutes

Page and Step

1

Explain that students will explore a case study of a child who has a

Page 98

rare disease.

Steps 1

• Display Master 4.1.

and 2

• Ask volunteers to read paragraphs aloud to the class.

Ask, “What would you do now that you have learned that your

Page 98

daughter has been diagnosed with leukemia?”

Step 3

Explain that after the upsetting visit to the doctor, Jason and Kim

Page 98

performed an Internet search on leukemia.

Step 4

Ask students:

Page 99

2

• “If you were Hanna’s parent, what information would you want to

Step 5

have about the disease?”

• “Where could you find that information?”

Give each student one copy of Masters 4.2 and 4.3. Instruct students Page 99

to rank on Master 4.3 the usefulness of the hits listed on Master 4.2.

Step 6

Display Master 4.3. Ask volunteers to report how they ranked the Web Page 101

hits.

Step 7

Arrange the class in pairs. Give each pair a copy of Masters 4.4 and Page 102

3

4.10. Ask students to read Master 4.10 and summarize the information Steps 8-p

on Master 4.4.

and 9-p

Reconvene the class and ask whether students have questions about

Page 102

the information from the Web hits.

Step 10

Remind students about the three general causes of disease. Ask, “What Page 103

types of information would you want to have in order to decide which

Steps 11 and 12

of the three causes of disease applies to leukemia?”

Explain that Jason and Kim have two children: Hanna, who has

Page 103

leukemia, and Rick, her healthy older brother. Also, say that there’s no Steps 13 and 14

4

history of leukemia in the family. Ask,

• “Does this rule out genetics as the cause of leukemia?”

• “What about environmental exposure or infections?”

Acknowledge that so far, there isn’t good evidence to suggest a cause

Page 103

for Hanna’s leukemia. Remind students about the Animation about

Step 15

Leukemia. Ask, “What happened to a stem cell that led to leukemia?”

5

Lesson 4

119

Explain that new mutations happen from exposure to sunlight and

Page 103

substances in the environment or from an uncorrected DNA-copying

Step 16

mistake. Mutations in genes associated with cell growth can lead to

cancer.

Explain that mutations can affect the number and appearance of

Page 104

chromosomes and that a photograph of chromosomes under a

Step 17

microscope is a karyotype. Give each student a copy of Master 4.5.

Instruct students to read Master 4.5 and answer the question at the Page 104

bottom. Explain that in leukemia, we expect a karyotype to show

Steps 18 and 19

three, not two, copies of at least one of the numbered (nonsex)

chromosomes.

Explain that students will now view karyotypes from Hanna and her

Page 106

immediate family. Ask students to predict whether each karyotype will

Step 20-p

appear normal or abnormal and to record in their notebooks whether

the evidence supports the predictions.

Give each student pair a copy of Master 4.11. Ask them to note

Page 106

whether their predictions were confirmed.

Step 21-p

Explain that students will now look at three different karyotypes from

Page 106

Hanna: from her blood, cheek, and hair follicles. Ask pairs to predict

Step 22a-p

how each karyotype will appear and to record their predictions.

Give each student pair a copy of Master 4.12. Ask students to note Page 106

whether their predictions were confirmed.

Step 22b-p

Ask, “How can you account for the appearance of the karyotypes taken

Page 106

from these three different tissues?”

Step 23-p

Activity 2: *Clinical Trials*

Estimated time: 50 minutes

Page and Step

Display Master 4.6. Ask volunteers to read it aloud.

Page 107

Step 1

1

Explain that doctors compare the effectiveness of cancer treatments by

Page 107

looking at the percentages of patients still alive

Step 2

after five years.

Explain that students will go back to the year 1970 and assume the

Page 107

roles of doctors trying to improve the survival rates of children with

Step 3

leukemia by conducting a clinical trial.

Give each student pair a copy of Master 4.7. Explain that it describes Page 107

the treatment options they can include in their trial.

Step 4

Tell students that they will work in their pairs to design and carry out a Page 110

2

clinical trial. Explain that

Step 5-p

• the standard therapy is a combination of the standard doses of

drugs A, B, and C,

• pairs will select drug doses and the use or nonuse of the central

nervous system treatment, and

• they will submit the design to you for analysis.

Explain that in clinical trials, an experimental treatment is compared

Page 110

with the standard treatment. Ask, “Should the clinical trial also include Step 6-p

a group that receives no treatment?”

3

Give each pair a copy of Master 4.8 . Instruct students to record on it Page 111

the treatment options they select, and then to submit it to you. Explain Steps 7a-p

what an Institutional Review Board is, and check that student designs

and 7b-p

test only one variable.

Once you’ve approved all the clinical trial designs, give each student

Page 111

pair the appropriate handout (Master 4.13, 4.14, 4.15, Step 8-p

or 4.16)

Ask student pairs to summarize the data and their conclusions and

Page 111

reasoning on Master 4.8.

Step 9-p

4

Reconvene the class and ask volunteers to report which treatment they Page 112

used and whether it was better than the standard one.

Step 10

Give each student a copy of Master 4.9 and explain that this is what Page 112

the doctor showed Hanna's parents to help them see how effective

Step 11

clinical trials have been in improving survival rates of children with

leukemia.

Remind students of the Web search they performed about leukemia.

Page 112

Ask, "What other results from the Web search could give us a different

Step 12

perspective about childhood leukemia?"

5

Lesson 4

121

Acknowledge that blogs and videos by cancer survivors can offer

Page 114

important perspectives on what it's like to live with that illness.

Step 13-p

Conclude by explaining that the class will conduct a brief interview

with a high school senior who was diagnosed with leukemia in eighth

grade.

Ask for one volunteer to play Hailey and one to play the interviewer,

Page 114

give each of them a copy of Master 4.17, and have them conduct the Steps 14-p

interview in front of the class.

and 15-p

Ask volunteers to describe their reactions to the interview.

Page 114

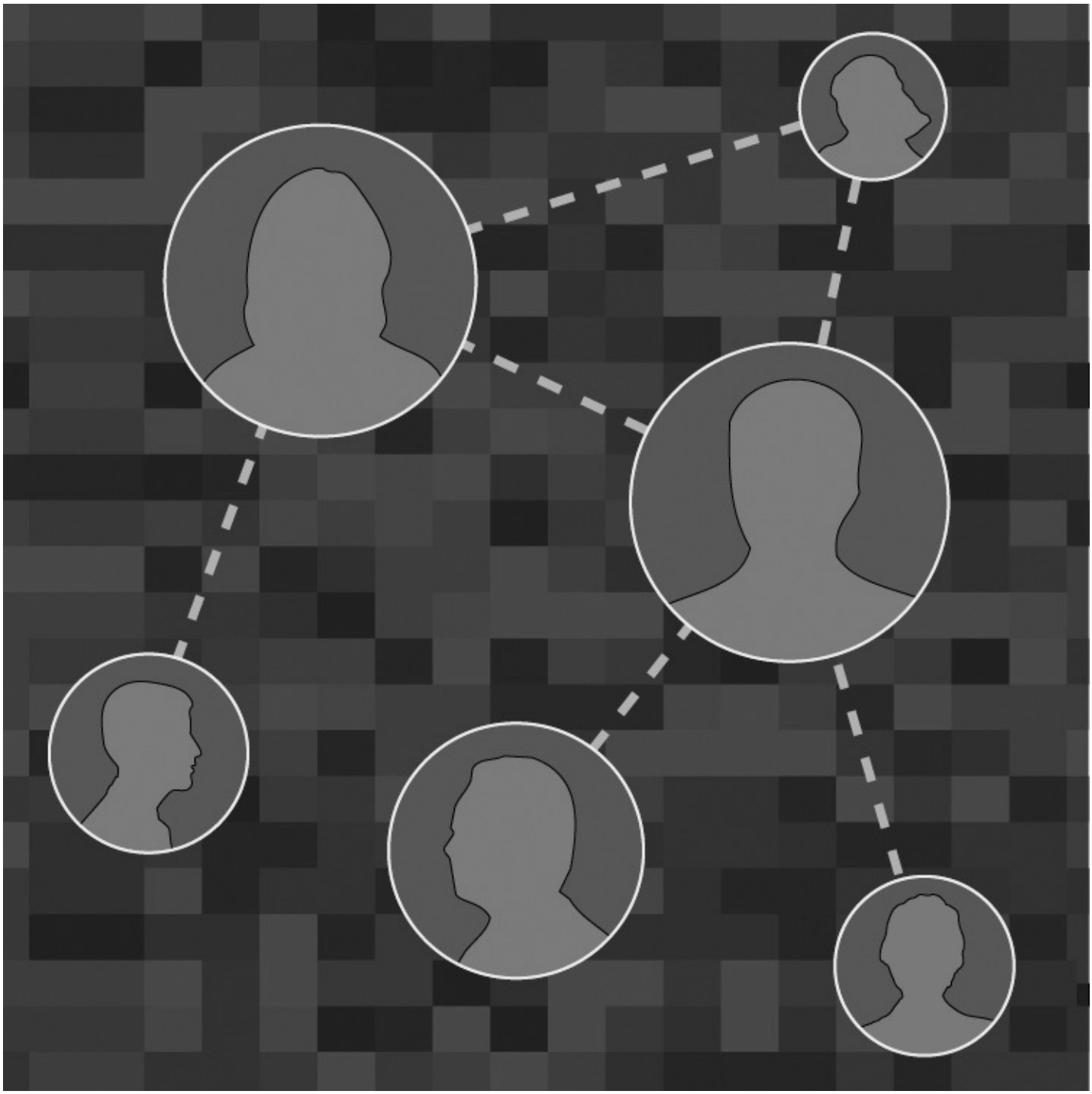
Step 16-p

= Involves making a transparency.

= Involves copying a master.

122

Rare Diseases and Scientific Inquiry



Lesson 5

Communicating about Rare Diseases

1

2

Evaluate

At a Glance

Overview

Lesson 5 gives students the opportunity to reflect on what they have

3

learned about rare diseases and scientific inquiry during this supplement.

Students role-play staff members of a patient-support organization and

are tasked with creating informational posters for the public about Marfan syndrome and childhood leukemia. After students create the posters, they evaluate another poster for a different disease. Finally, students return to the reality TV show scenario that began the supplement. They revisit their initial ideas about rare disease and their attitudes toward people affected by them. They reexamine their answers to the questions about rare diseases posed in Lesson 1 and discuss how their thinking has changed.

4

Major Concepts

• Diseases have three main causes:

– genetics

– environmental exposure

– infectious agents

• Rare diseases may become common, and common diseases may become

rare.

• Some rare diseases can be cured, while many others can be managed

through treatment.

• People with rare diseases must sometimes cope with the stigma

associated with their condition.

5

123

Objectives

After completing this lesson, students will have

• revisited their preconceptions about the nature of disease in light of scientific conceptions,

• summarized information about childhood leukemia and Marfan

syndrome, and

• considered their feelings about people affected by rare diseases.

Teacher Background

Consult the following sections in Information about Rare Diseases and Scientific Inquiry:

2.0 The Impact of Genomics on Rare Diseases (pages 24–26)

3.0 Rare Infectious Diseases (page 26)

4.0 Rare Diseases Caused by Environmental Toxins (pages 27–28)

5.1 Necrotizing Fasciitis (pages 28–29)

5.2 Marfan Syndrome (pages 29–31)

5.3 Childhood Leukemia (pages 31–33)

In Advance

Web-Based Activities

Activity	**Web Component?**
1	**No**
2	**Yes**

Photocopies, Transparencies, Equipment, and Materials

Photocopies and Transparencies

Activity 1: Creating an Informational Poster

1 transparency and 1 copy of Master 5.1 for each student pair

1 copy of Master 5.2 for each student pair addressing Marfan syndrome

1 copy of Master 5.3 for each student pair addressing childhood

leukemia

1 transparency and 1 copy for each student pair of Master 5.4

1 copy of Master 5.5 for each student pair

Activity 2: Reflecting on Rare Diseases

For Classes Using the Web-Based Version

1 copy of Master 5.6 for each student

Continued

Photocopies and Transparencies

Activity 2: Reflecting on Rare Diseases

For Classes Using the Print-Based Version

1 copy of Master 5.6 for each student

1 transparency of Master 5.7

1

Equipment and Materials

For Activity 1, students will need chart paper and colored marking pens.

For Activity 2, Web-based version, students will need computers with Internet access.

Preparation

Activity 1

Gather chart paper and colored marking pens for each student pair. Make photocopies and transparencies.

2

Activity 2

For classrooms using the Web version, verify that the

computer lab is reserved for your class or that classroom

computers are set up for the activities. Refer to Using the

Web Site for details about the site. Check that the Internet

connection is working properly.

Log on to the Web Portion of Student Activities section of the site at

3

http://science.education.nih.gov/supplements/rarediseases/student

Select “Lesson 5: Communicating about Rare Diseases” so students can

begin the activity right away.

Procedure

Activity 1: *Creating an Informational Poster*

4

Estimated time: 50 minutes

Note: This is an Evaluate lesson. It’s not designed to teach new content but rather to give you a chance to assess how well students

have learned the major concepts about rare diseases and scientific

inquiry.

1.

Begin by explaining that in this final lesson of the supplement,

students will play the roles of staff members working for an

5

Lesson 5

125

organization that informs and support patients with rare

diseases and their families. Explain the following:

• Many rare diseases have support groups that raise awareness

and money to support research about the disease.

• The task is for pairs to prepare informational posters that

Content Standard C:

explain important aspects of a rare disease to patients, family

Disease is a

members, and other interested people.

breakdown in

structures of functions

Students may feel unqualified to prepare informational posters

of an organism. Some

about rare diseases. You can explain that the posters will deal with

diseases are the result

the rare diseases they have been studying. Furthermore, the goal

of the poster is to communicate information to the public, so the

of intrinsic failures of

posters should use language that everyone can understand.

the system. Others are

the result of damage

2.

Arrange students into pairs again. Explain that each pair will

by infection by other

create a poster about childhood leukemia or Marfan syndrome.

organisms.

Assign half of the pairs to childhood leukemia and the other

half to Marfan syndrome. Explain that after each pair creates a

poster, they will evaluate a poster about the other rare disease.

You may allow student pairs to select the disease they prefer. If

selections heavily favor one disease over the other, you may need to

instruct some pairs to switch diseases to maintain a balance between

the two.

Tip from the field test: If your classroom has the

technical capacity, consider allowing students to create

a PowerPoint presentation instead of a poster.

3.

Display Master 5.1, *Guidelines for the Poster,* and give each pair a copy to use as a reference. Explain that the handout lists

Content Standard A:

the types of information that should be in the poster. Briefly

Students should base

go over the items on the handout and answer any questions

their explanations on

students have.

what they observed,

and as they develop

Make sure that students have access to the notebooks that contain

cognitive skills,

their work from previous lessons. This work will help students

complete the first part of the poster.

they should be

able to differentiate

Note: The purpose of this activity is to assess students' learning from the explanation from

previous lessons. Therefore, do not allow students to conduct a research description—proving

project using the Internet or other outside resources.

causes for effects

and establishing

4.

Explain that the second part of the poster will contain a brief

summary of a recent clinical trial or research study about the

relationships based

disease. Give each student pair one copy of Master 5.2, *Research*

on evidence and

Study on Marfan Syndrome*, or Master 5.3, *Clinical Trial on

logical argument.

***Childhood Leukemia*, depending on student preference.**

These handouts contain the information needed to complete the

second part of the poster.

Marfan study

Students should conclude that the drug losartan helped keep the aortas

of mice with the Marfan mutation at a healthy size. This suggests that

1

the drug also may be able to help humans with Marfan syndrome.

Leukemia clinical trial

Students should conclude that the survival rate of patients who

received drug combination therapy with brain irradiation was

essentially the same as that of patients who received combination

drug therapy alone. This means that patients can be spared the brain

irradiation and the risk of its harmful side effects.

5.

Display Master 5.4,

2

***Evaluation Rubric*. Explain that student**

pairs will use it to evaluate the poster created by another pair.

Briefly go over the criteria on the handout.

It’s important to provide the pairs with evaluation criteria before they create the posters. Otherwise, they may feel that it is unfair to be given this information after it’s too late to revise the posters.

6.

Make available to pairs chart paper and colored marking pens. Explain that pairs will first make an outline of the information they plan to include on the poster. When they are satisfied with

3

it, they should transfer it to a piece of chart paper.

7.

As the student pairs work, circulate around the room and assign a code number to each poster.

Allow students at least 15 minutes to complete this task. The code number allows you to know which students worked on which poster and prevents the students from knowing who created the poster they will evaluate.

8.

After student pairs have completed the posters and each has

4

been assigned a code number, collect all posters.

Place the posters about childhood leukemia in one pile and those about Marfan syndrome in another pile.

9.

Give each pair a poster to evaluate. Make sure that each pair evaluates a poster about the rare disease they did not create a

poster for.

If multiple classes will be making posters, consider having one class

5

serve as peer reviewers for another class.

Lesson 5

127

10. Give each student pair one copy each of Master 5.4 and Master

5.5, *Poster Score Sheet.*

Give students about 20 minutes to complete the evaluation, and

then collect the score sheets. Of course, the students' explanations

for their scores are more revealing than the numbers themselves.

Activity 2: *Reflecting on Rare Diseases*

Estimated time: 50 minutes

1.

Remind the class about the producer of the reality TV show who

wanted to film a student with a rare disease joining the class.

Instruct students to look in their notebooks where, in Lesson 1,

they wrote down questions they would ask the student with the

rare disease.

(For print version, skip to Step 2-p on page 130.)

In classrooms using the Web-based activity:

2-w. Explain that student pairs will go to their computers and watch a video made by a young man with Marfan syndrome. Instruct students to keep in mind the questions they posed and the feelings they expressed about rare diseases and the people affected by them.

Computers should be at the URL:

http://science.education.nih.gov/supplements/rarediseases/student

This is a menu page that contains a link for this activity.

3-w. Direct students to their computer stations and instruct them to click on "Lesson 5: Communicating about Rare Diseases." The video is about 12 minutes long and illustrates the story of Kevin, a young man who has Marfan syndrome.

4-w. After they have watched the video, allow students to express their feelings about it.

If students focus on feelings of sorrow or pity, call attention to comments made by Kevin's mother about how important he is to their family and to those around him. Marfan syndrome certainly has affected him, but not only in negative ways. It has helped Kevin direct his life.

5-w. Ask for volunteers to read from their notebooks

• a question they wanted to ask the student with the rare

disease *or*

• a feeling they expressed about having the student join the

class.

1

If their thinking has changed since the beginning of the

supplement, ask them to explain how and why.

The point of this step is to revisit questions, concerns, and fears

about people with rare diseases that students expressed at the

start of the supplement. We hope that after learning about rare

diseases and hearing from people who live with them, students

become more empathetic and sensitive to those who cope with

rare diseases.

6-w. Explain that you want to conclude the supplement by

2

revisiting the students' initial ideas about disease. Give

each student one copy of Master 5.6, *What Do You Think*

***Now?* Instruct students to answer each question on the handout.**

Give students 5–10 minutes to answer the questions. Students may recognize that they answered these questions during the Lesson 1.

Answering the same questions gives them the opportunity to

reflect on how their thinking has changed as a consequence of

participating in the supplement.

3

7-w. Have students retrieve the copy of Master 1.2, *Thinking about*

***Disease*, that they filled out in Lesson 1. Instruct students to compare the answers they just wrote with those on Master 1.2.**

8-w. After students have had a chance to compare both sets of answers, ask the following:

• “Have any of your answers changed since Lesson 1?”

• “If so, what caused your thinking to change?”

Allow different students to respond. Some of the students’ answers

to the questions will probably have changed. Even if some students’ attitudes are essentially the same, the knowledge gained during the supplement may influence their opinions later, after they have had more experiences.

End of Web-based activity.

Lesson 5

In classroom using the print version of the activity:

2-p. Display Master 5.7, *Another Letter from the Producer*.

Ask for a volunteer to read it aloud to the class.

3-p. Remind students that during Lesson 1, they wrote in their notebooks some questions they would ask a student with a rare disease who was about to join the class. Instruct students to look back at the questions they posed and the feelings they expressed about sharing their classroom with this student.

4-p. Explain that you wonder whether participating in the lessons in this supplement has caused anyone to change their attitude

about people with rare disease. Ask for volunteers to read from

their notebooks

• a question they wanted to ask the student with a rare disease

or

• a feeling they expressed about having the student join the

class.

If their thinking has changed since the beginning of the

supplement, ask them to explain how and why.

The point of this step is to revisit questions, concerns, and fears

about people with rare diseases that students expressed at the start

of the supplement. We hope that after learning about rare diseases

and hearing from people who live with them, students become

more empathetic and sensitive to those who cope with

rare diseases.

5-p. Explain that you want to conclude the supplement by revisiting the students' initial ideas about disease. Give each student one

copy of Master 5.6, *What Do You Think Now?* Instruct students to answer each question on the handout.

Give students 5–10 minutes to answer the questions. Students may recognize that they answered these questions during the Lesson 1.

Answering the same questions gives them an opportunity to

reflect on how their thinking has changed as a consequence of

participating in the supplement.

6-p. Have students retrieve the copy of Master 1.2, *Thinking about*

***Disease,* they filled out in Lesson 1. Instruct them to compare the answers on Master 5.6 with those on Master 1.2.**

7-p. After students have had a chance to compare both sets of answers, ask the following:

• "Have any of your answers changed since Lesson 1?"

• "If so, what caused your thinking to change?"

Allow different students to respond. Some of the students' answers to the questions will probably have changed. Even if some students'

1

attitudes are essentially the same, the knowledge gained during the supplement may influence their opinions later, after they have had more experiences.

2

3

4

5

Lesson 5

131

Lesson 5 Organizer: Web Version

Activity 1: *Creating an Informational Poster*

Estimated time: 50 minutes

Page and Step

Explain that students will play the roles of staff members

Page 125

working for a patient support group. Student pairs will prepare Step 1

informational posters for the public.

Arrange the class in pairs again. Explain that each pair will

Page 126

make a poster about a rare disease (half will address Marfan

Step 2

syndrome and half will address childhood leukemia) and then

evaluate another pair's poster.

Display Master 5.1 and give each pair a copy.

Page 126

Go over the master and answer students' questions.

Step 3

Explain that the second part of the poster will contain a

Page 126

summary of a clinical trial or research study. Give each pair

Step 4

a copy of either Master 5.2 or Master 5.3, depending on student preference.

Display Master 5.4, and explain that students will use it to Page 127

evaluate another pair's poster.

Step 5

Give pairs chart paper and marking pens.

Page 127

• Instruct students to first make an outline of the poster,

Steps 6–8

then transfer it to the chart paper.

• Circulate around the room and assign a code number to

each poster.

• When students have finished, collect the posters.

Give each pair a poster of the disease they did not work on.

Page 127

Step 9

Give each pair a copy of Masters 5.4 and 5.5. After students Page 128

have completed the work, collect the score sheets.

Step 10

Activity 2: *Reflecting on Rare Diseases*

Estimated time: 50 minutes

Page and Step

Remind the class about the reality TV scenario from Lesson 1.

Page 128

Instruct students to retrieve the questions and feelings about

Step 1

the scenario they recorded in their notebooks.

1

Tell students to watch a video on their computers made

Pages 128

by a young man who has Marfan syndrome (at “Lesson 5:

Steps 2w–4w

Communicating about Rare Diseases”). Afterwards, allow

students to express their feelings about the video.

Ask volunteers to read from their notebooks

Page 129

• a question they wanted to ask the student with the rare

Step 5-w

disease *or*

• a feeling they expressed about having the student join

their class.

2

If their thinking has changed since the beginning of the

supplement, ask them to explain how and why.

Revisit students' initial ideas about disease.

Page 129

Give every student a copy of Master 5.6, and instruct them to

Step 6-w

answer the questions on it.

Have students retrieve their copies of Master 1.2 and

Page 129

compare these answers with those on Master 5.6.

Step 7-w

Conclude by asking,

Page 129

• "Have any of your answers changed since Lesson 1?"

Step 8-w

3

• "If so, what caused your thinking to change?"

= Involves making a transparency.

= Involves copying a master.

= Involves using the Internet.

4

5

Lesson 5

133

Lesson 5 Organizer: Print Version

Activity 1: *Creating an Informational Poster*

Estimated time: 50 minutes

Page and Step

Explain that students will play the roles of staff members

Page 125

working for a patient support group. Student pairs will prepare

Step 1

informational posters for the public.

Arrange the class in pairs again. Explain that each pair will

Page 126

make a poster about a rare disease (half will address Marfan

Step 2

syndrome and half will address childhood leukemia) and then

evaluate another pair's poster.

Display Master 5.1 and give each pair a copy. Go over the

Page 126

master and answer students' questions.

Step 3

Explain that the second part of the poster will contain a summary Page 126

of a clinical trial or research study. Give each pair a copy of either

Step 4

Master 5.2 or Master 5.3, depending on student preference.

Display Master 5.4, and explain that students will use it to

Page 127

evaluate another pair's poster.

Step 5

Give pairs chart paper and marking pens.

Page 127

• Instruct students to first make an outline of the poster, then

Steps 6–8

transfer it to the chart paper.

• Circulate around the room and assign a code number to

each poster.

• When students have finished, collect the posters.

Give each pair a poster of the disease they did not work on.

Page 127

Step 9

Give each pair a copy of Masters 5.4 and 5.5. After students Page 128

have completed the work, collect the score sheets.

Step 10

Activity 2: *Reflecting on Rare Diseases*

Estimated time: 50 minutes

Page and Step

Remind the class about the reality TV scenario from Lesson 1. Page 128

Instruct students to retrieve the questions and feelings about

Step 1

the scenario they recorded in their notebooks.

1

Display Master 5.7, and ask a volunteer to read it aloud. Ask

Page 130

students to reflect on the questions and feelings they wrote

Steps 2-p

about in their notebooks during Lesson 1.

and 3-p

Ask volunteers to read from their notebooks

Page 130

• a question they wanted to ask the student with the rare

Step 4-p

disease *or*

• a feeling they expressed about having the student join

their class.

If their thinking has changed since the beginning of the

2

supplement, ask them to explain how and why.

Revisit students' initial ideas about disease. Give every

Page 130

student a copy of Master 5.6, and instruct them to answer

Step 5-p

the questions on it.

Have students retrieve their copies of Master 1.2 and

Page 130

compare those answers with the ones on Master 5.6.

Step 6-p

Conclude by asking,

Page 131

• “Have any of your answers changed since Lesson 1?”

Step 7-p

• “If so, what caused your thinking to change?”

3

= Involves making a transparency.

= Involves copying a master.

4

5

Lesson 5

135

Masters

Lesson 1—What Is a Rare Disease?

Activity 1: **What Is a Rare Disease?**

Master 1.1, *Letter from a Producer* ..... transparency Master 1.2, *Thinking about Disease* ..... student copies Lesson 2—What Causes Rare Diseases?

Activity 1: **Causes of Disease**

Master 2.1, *Medical Officer Report Form* ..... transparency and student copies for each pair

Master 2.2, *Visits to the Infirmary, Week 1 ..... student copies for each pair**
Master 2.3, *Test Results, Week 1 ..... student copies for each pair**

Activity 2: **Is a Rare Disease Present?**

Master 2.4, ***Follow-up on Week 1 Infirmary Visits**** **..... student copies for each pair**
Master 2.5, ***Visits to the Infirmary, Week 2**** **..... student copies for each pair**
Master 2.6, ***Medical Reference Manual: Necrotizing Fasciitis**** **..... student copies for each pair**
Master 2.7, ***Questions about a Rare Disease*** **..... student copies for each pair**
Lesson 3—The Diffi culty of Diagnosis

Activity 1: **A Parent's Dilemma**

Master 3.1, ***To Play or Not to Play?*** **..... transparency Master 3.2,** ***Medical Specialty Report Form*** **..... student copies Master 3.3,** ***Heart and Circulatory System**** **..... student copies for each group of 4**

Master 3.4, ***Vision System**** **..... student copies for each group of 4**

Master 3.5, ***Respiratory System**** **..... student copies for each group of 4**

Master 3.6, ***Skeletal System**** **..... student copies for each group of 4**

Activity 2: **Connective Tissue**

Master 3.7, ***Measuring Elasticity*** **..... transparency**

Activity 3: **A Common Thread**

Master 3.8, ***Diagnosing a Connective Tissue Disorder.*** **..... student copies for each pair**
Master 3.9, ***Medical Reference Manual: Disorders***

of the Connective Tissue* **..... student copies for each pair**
Master 3.10, ***Patrick's Family**** **..... student copies for each pair**
Master 3.11, ***Living with Marfan Syndrome**** **..... transparency Lesson 4—The Importance of Medical Research**

Activity 1: **An Unwelcome Diagnosis**

Master 4.1, ***Doctor Visits 1 and 2*** **..... transparency Master 4.2,** ***Internet Search Results*** **..... student copies**

***Print version only**

Master 4.3, ***Evaluating Internet Search Results*** **..... transparency and student copies Master 4.4,** ***Summarizing Information about Leukemia*** **..... student copies for each pair Master 4.5,** ***Karyotype*** **..... student copies**

Activity 2: **Clinical Trials**

Master 4.6, *Another Doctor Visit* ..... transparency Master 4.7, *Treating Leukemia* ..... student copies for each pair Master 4.8, *Designing a Clinical Trial* ..... student copies for each pair Master 4.9, *Survival Rates for Children with Leukemia* ..... student copies for each pair Master 4.10, *Information about Leukemia ..... student copies for each pair Master 4.11, *Family Karyotypes** ..... student copies Master 4.12, *Hanna's Karyotypes** ..... student copies Master 4.13, *Changing the Dose of Drug A** ..... student copies for each pair Master 4.14, *Changing the Dose of Drug B** ..... student copies for each pair Master 4.15, *Changing the Dose of Drug C** ..... student copies for each pair Master 4.16, *Central Nervous System Treatment** ..... student copies for each pair Master 4.17, *Interview with Hailey** ..... 2 copies for the class Lesson 5—Communicating about Rare Diseases**

Activity 1: **Creating an Informational Poster**

Master 5.1, *Guidelines for the Poster* ..... transparency and student copies for each pair

Master 5.2, *Research Study on Marfan Syndrome* ..... student copies for each pair
Master 5.3, *Clinical Trial on Childhood Leukemia* ..... student copies for each pair
Master 5.4, *Evaluation Rubric for Poster* ..... transparency and student copies for each pair

Master 5.5, *Poster Score Sheet* ..... student copies for each pair

Activity 2: **Refl ecting on Rare Diseases**

Master 5.6, *What Do You Think Now?* ..... student copies Master 5.7, *Another Letter from the Producer ..... transparency**

***Print version only**

PEOPLE REALITY

Productions

Letter from a Producer

Dear Principal:

I am a producer for People Reality Productions, a company that develops reality television shows for broadcast over several cable TV channels. We are thinking about creating a series that follows the life of a student who has a rare disease.

We are still working out the details of the series. At this point, we haven't identified the student who will participate or even which rare disease will be featured in the series. As a first step, we are interested in learning what concerns and questions your teachers and students have about a student with a rare disease joining their class.

Please share this letter with your teachers. After they have had a chance to discuss it with their students, I will call you to learn about their thoughts and concerns.

Thank you for your help with this project.

Sincerely,

Vincent Shifflett

Senior Producer

People Reality Productions

Master 1.1

Thinking about Disease

Name:

Questions

1. What is a disease?

2. How do doctors tell if someone has a disease?

3. What do you think causes disease?

4. Make a list of list 10 different diseases.

Table 1. List of Diseases

5. What does it mean to call a disease “rare”?

6. In simple terms, curing a disease means that the patient has been restored to good health and there is little chance of the disease coming back.

It is not possible to cure all diseases. Controlling a disease means that the disease symptoms are lessened and the quality of the life for the patient is improved, but the disease has not been cured.

Which of the diseases you listed in Step 4 do you think are curable, controllable, or incurable?

Master 1.2

Medical Offi cer Report Form

Name(s):

Questions

1. Summarize the reasons that soldiers came to the infi rmary during Week 1.

2. Fill out the form for ordering lab tests.

Test Order Form

Soldier

Test ordered

Why was the test ordered?

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

Master 2.1

Visits to the Infi rmary, Week 1

Soldier Barracks

What’s

Test

Test

Diagnosis Treatment

wrong?

ordered

results

1

A

Sore, red,

itchy eyes

2

D

Sore toe

3

A

Sore, red,

itchy eyes

4

A

Sore, red,

itchy eyes

5

G

Sore throat

6

A

Sore, red,

itchy eyes

7

E

Skin rash

8

A

Sore, red,

itchy eyes

9

F

Cut on left

leg

10

G

Sore throat

11

I

Shortness of

breath

12

A

Sore, red,

itchy eyes

13

H

Sore toe

14

G

Sore throat

15

E

Skin rash

16

G

Sore throat

17

G

Sore throat

18

B

Ankle pain

19

G

Sore throat

20

D

Sore toe

21

C

Sore toe

Master 2.2

Permission granted for classroom use.

Test Results, Week 1

Soldier Barracks

What’s

Test

Test

Diagnosis Treatment

wrong?

ordered

results

1

A

Sore, red,

Test 1

+ for bacteria

Pinkeye

Antibiotic

itchy eyes

C

eyedrops

2

D

Sore toe

Test 1

+ for bacteria

Blister from Dressing

A

boots

3

A

Sore, red,

Test 1

+ for bacteria

Pinkeye

Antibiotic

itchy eyes

C

eyedrops

4

A

Sore, red,

Test 1

+ for bacteria

Pinkeye

Antibiotic

itchy eyes

C

eyedrops

5

G

Sore throat

Test 1

+ for bacteria

Strep throat

Antibiotic

A

6

A

Sore, red,

Test 1

+ for bacteria

Pinkeye

Antibiotic

itchy eyes

C

eyedrops

7

E

Skin rash

Test 2

+ for poison

Poison ivy

Steroid skin

ivy

cream

8

A

Sore, red,

Test 1

+ for bacteria

Pinkeye

Antibiotic

itchy eyes

C

eyedrops

9

F

Cut on left

No test

Stitches

leg

10

G

Sore throat

Test 1

+ for bacteria

Strep throat

Antibiotic

A

11

I

Shortness of

No test

Asthma

Inhaler

breath

12

A

Sore, red,

Test 1

+ for bacteria

Pinkeye

Antibiotic

itchy eyes

C

eyedrops

13

H

Sore toe

Test 1

+ for bacteria

Blister from Dressing

A

boots

14

G

Sore throat

Test 1

+ for bacteria

Strep throat

Antibiotic

A

15

E

Skin rash

Test 2

+ for poison

Poison ivy

Steroid skin

ivy

cream

16

G

Sore throat

Test 1

+ for bacteria

Strep throat

Antibiotic

A

17

G

Sore throat

Test 1

+ for bacteria

Strep throat

Antibiotic

A

18

B

Ankle pain

No test

X-ray

No break

Bandage

19

G

Sore throat

Test 1

+ for bacteria

Strep throat

Antibiotic

A

20

D

Sore toe

Test 1

– for all

Blister from Dressing

bacteria

boots

21

C

Sore toe

Test 1

+ for bacteria

Blister from Dressing

A

boots

Master 2.3

Permission granted for classroom use.

Follow-up on Week 1 Infi rmary Visits

Summary of Patients' Responses to Treatment from Week 1

• Six soldiers from Barracks A with pinkeye tested positive for infection by bacterial species C. They were treated with eyedrops containing antibiotics.

In all cases, the infection has cleared up.

• Six soldiers from Barracks G with sore throats tested positive for infection by bacterial species A. They were treated with antibiotics. Although two soldiers returned to the infi rmary, all are responding to the antibiotics and the infections have largely disappeared.

• Four soldiers developed blisters from wearing new boots. Three of the four tested positive for infection by bacterial species A, and the fourth soldier tested negative for species A, B, and C. One soldier received a cut on the left leg, which was closed with stitches. He has no evidence of infection.

• One soldier twisted his ankle. X-rays showed no broken bones. The ankle was bandaged, and the soldier has been assigned to light duty.

• Two soldiers from Barracks E tested positive for exposure to poison ivy. They were treated with steroid cream, and the skin rashes are disappearing.

• One soldier, who was short of breath, was diagnosed as having asthma and was given an inhaler, which eased her symptoms.

Master 2.4

Permission granted for classroom use.

Visits to the Infi rmary, Week 2

Return Visits to the Infirmary from Week 1 Soldier Visits

Soldier Barracks What’s wrong? Tests ordered Test results Diagnosis Treatment 2

D

Swollen,

blistered

lower leg

16

G

Sore throat

19

G

Sore throat

New Visits to the Infirmary, Week 2

Soldier Barracks What’s wrong? Tests ordered Test results Diagnosis Treatment 22

G

Sore throat

23

A

Sore throat

24

E

Cut on head

25

G

Sore throat

26

G

Sore throat

27

B

Skin rash

28

G

Sore throat

29

D

Ankle pain

30

A

Sore throat

31

B

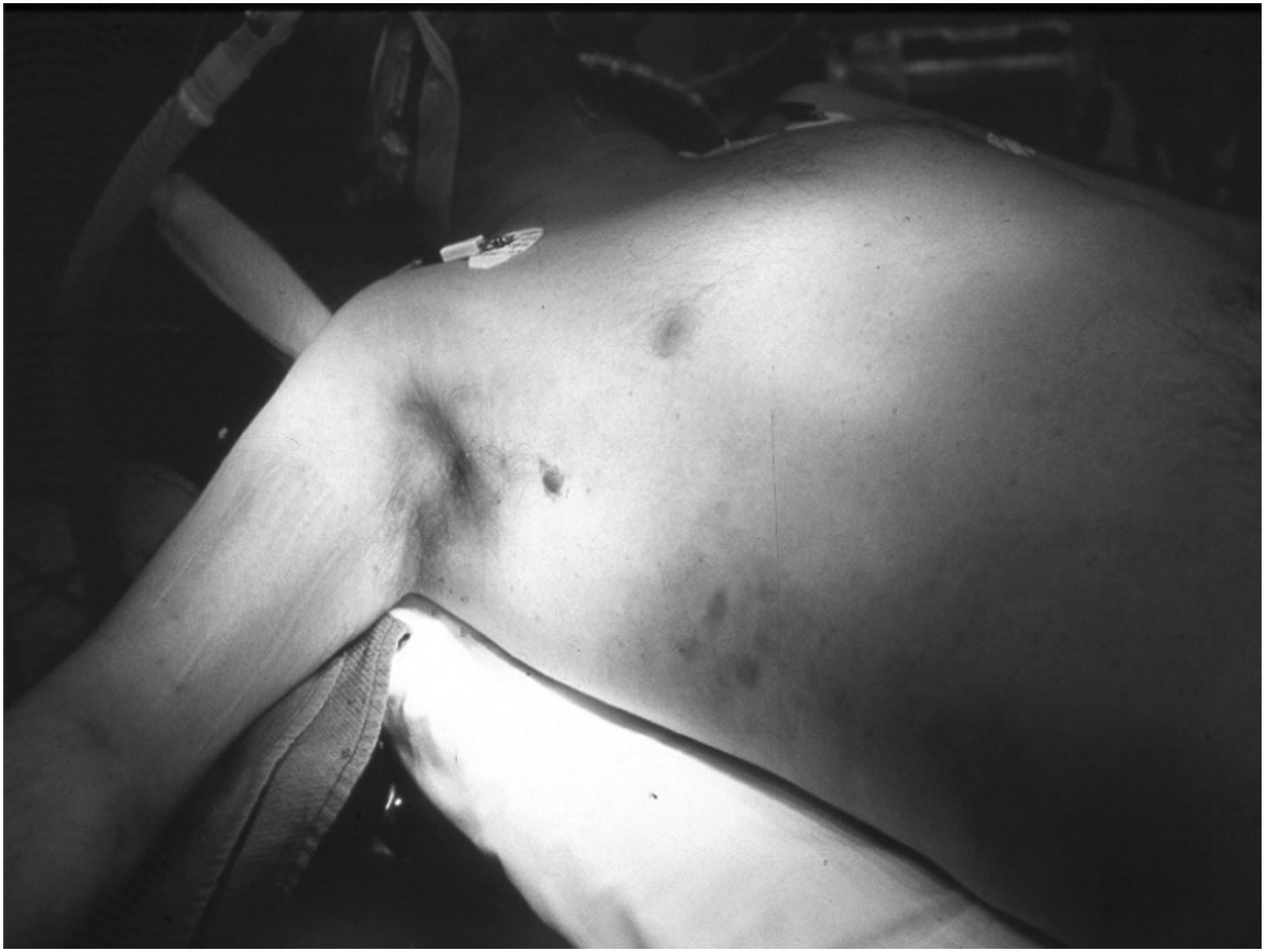
Sore toe

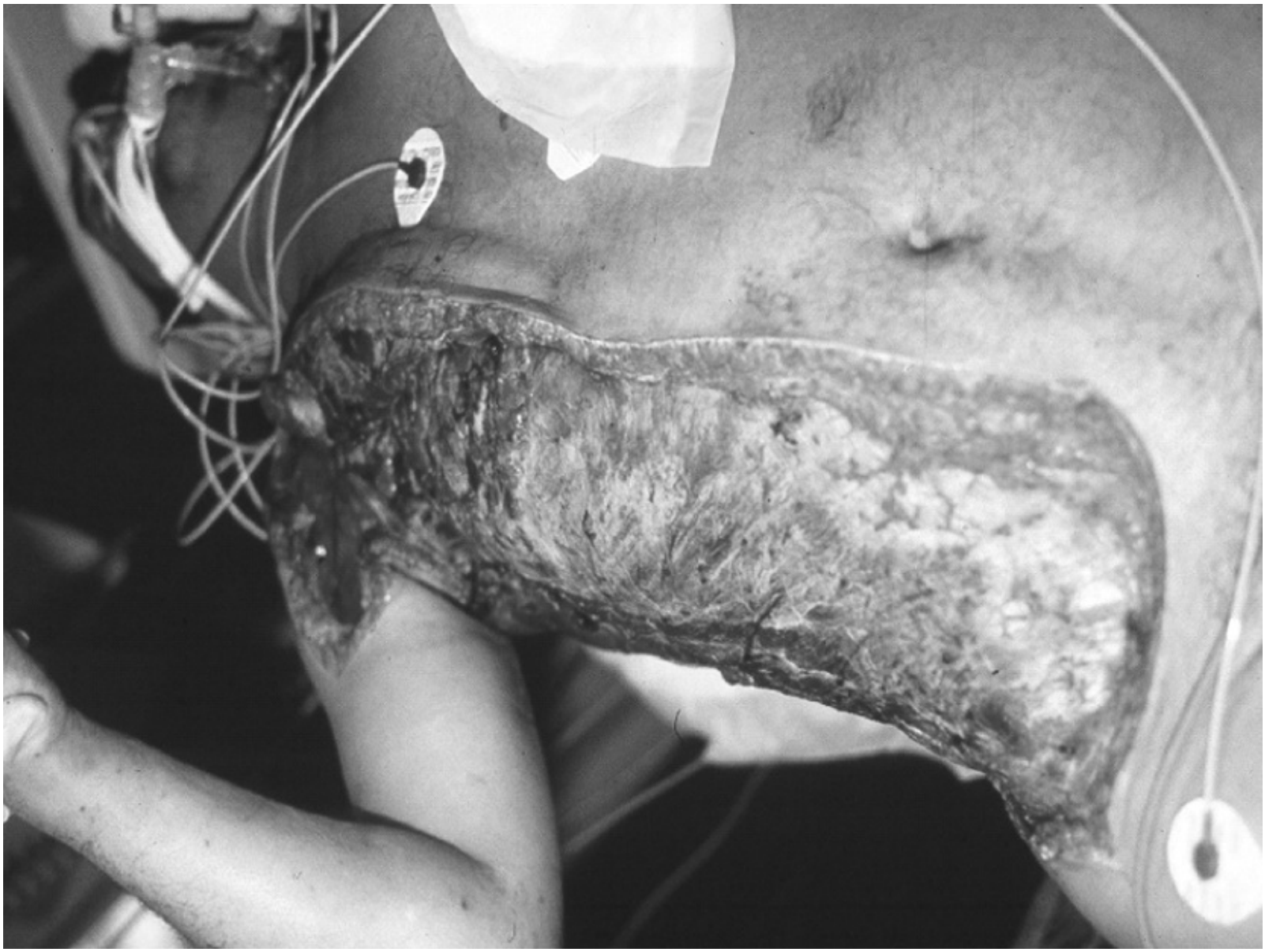
32

F

Skin rash

Master 2.5





Medical Reference Manual:

Necrotizing Fasciitis (Flesh-Eating Bacteria)

What is it?

Flesh-eating disease is a bacterial infection that destroys skin and fat tissue. The disease is very rare. The odds of getting it are about 1 in 100,000. However, it is very serious. About 2 out of 10 people who get this infection die from it.

What causes it?

The disease can be caused by different species of bacteria, including the one that causes strep throat. The bacteria enter the body through open wounds, where they interact with the immune system to produce the disease. Flesh-eating disease is rare because the immune system of most people will stop the infection before it becomes serious.

What are the symptoms?

The skin reddens, becomes swollen, and is painful to the touch. Other symptoms include nausea,

vomiting, and diarrhea. The symptoms start suddenly, may get better for a day or two, then quickly worsen. If not treated, the disease may result in organ failure and death.

Figure 1. Early infection. **(Donald E. Low, University**

Figure 2. Late infection. **(Donald E. Low,**

Health Network/Mount Sinai Hospital)

University Health Network/Mount Sinai Hospital)

How is it treated?

Patients with flesh-eating disease need immediate hospital care. Treatment involves antibiotics and surgery to remove diseased tissue and stop the spread of the disease.

Master 2.6

Permission granted for classroom use.

Questions about a Rare Disease

Name(s):

1. What evidence suggests that bacterial species A causes both sore throat and foot infection?

2. What evidence suggests that the soldier with the foot infection has fl esh-eating disease?

3. Why are there many cases of sore throat but only one case of fl esh-eating disease?

4. What evidence is there that fl esh-eating disease is a rare disease?

5. What should be the next step in treating the soldier with the foot infection?

Explain your reasoning.

Master 2.7

Permission granted for classroom use.

To Play or Not to Play?

Patrick is a 13-year-old middle school student who loves to play basketball. He came home excited from school and explained to his parents that the school basketball team will be holding tryouts next month and he wants to participate.

Patrick's parents are both happy and concerned for him. They are happy because they know Patrick loves sports, and they feel that the exercise will be good for him. They also know that Patrick has been occasionally teased because he is tall and thin. Maybe by joining the basketball team he will make new friends and feel more accepted by his classmates.

Patrick's parents are concerned because he has some health problems. When Patrick was a toddler, the family doctor diagnosed him with a heart murmur.

The doctor explained that a heart murmur refers to a sound that the blood makes as it flows through the heart. She further explained that heart murmurs are usually harmless and that Patrick could lead a normal life.

When he was nine, Patrick developed a problem with his eyesight, and it was discovered that one of his eye lenses was detached and had to be repaired.

When Patrick was 10, he was diagnosed with asthma. The doctor explained that asthma causes the tubes carrying air in and out of the lungs to become sore and swollen. This can cause coughing and wheezing and make it difficult to breathe.

The doctor created a treatment plan for Patrick that helped him recognize his symptoms and use an inhaler to make breathing easier. She also explained that, with proper management of his asthma, Patrick could play sports and that the exercise might even improve his condition.

Finally, just last year, Patrick was diagnosed with scoliosis, or curvature of the spine. The doctor explained that Patrick's scoliosis was moderate and, as with most children, the cause was unknown. He further explained that in 90 percent of cases, no future treatment is needed.

Master 3.1

Medical Specialty Report Form

Name(s):

Patient's name

Medical specialty

Patient's medical history

Results from physical exam

Possible causes

Copyright © 2011 BSCS.

Master 3.2

Permission granted for classroom use.

Heart and Circulatory System

Cardiologist Report

Medical history

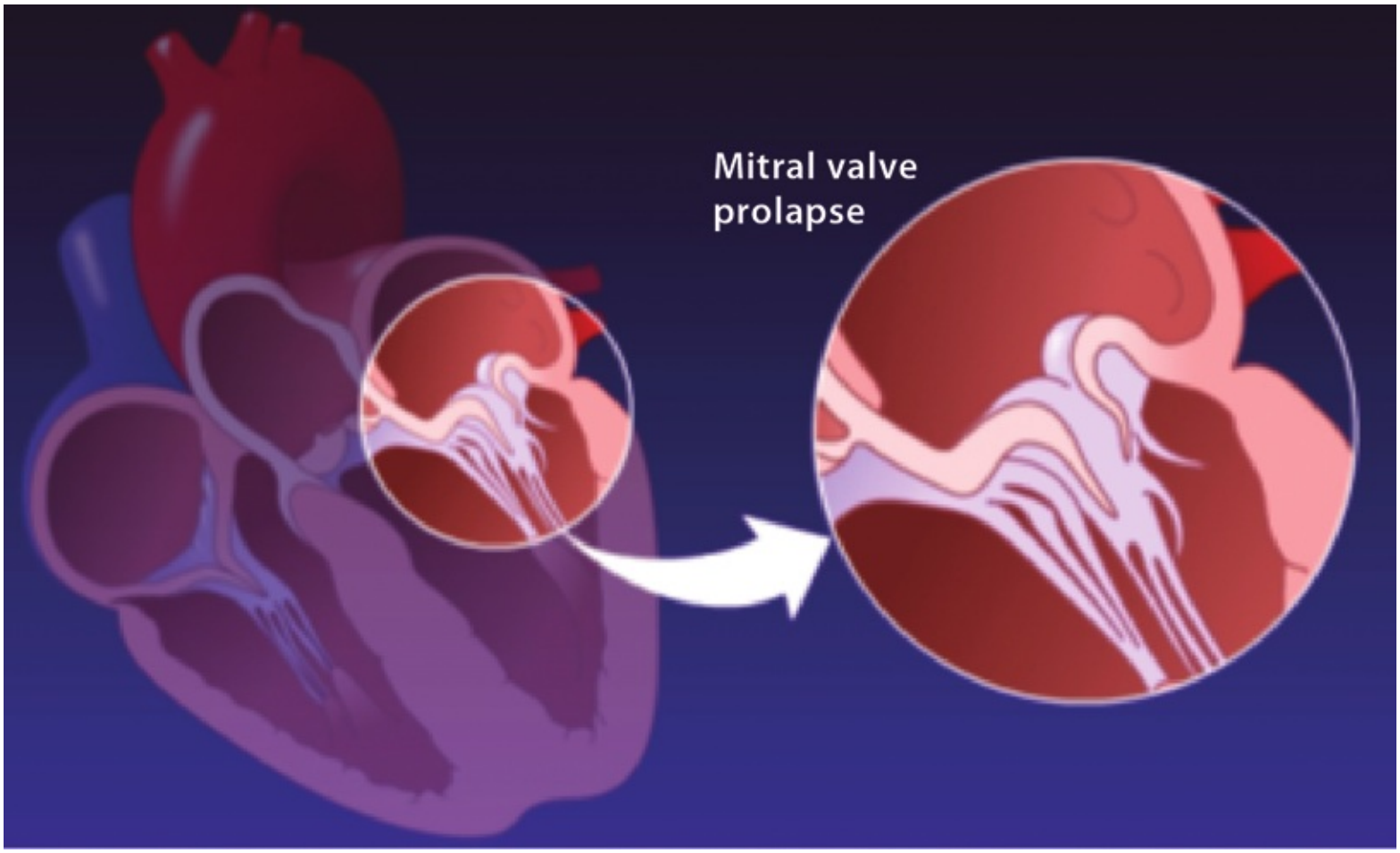
Patient was previously diagnosed with a heart murmur. An echocardiogram reveals mitral valve prolapse and an enlarged aorta.

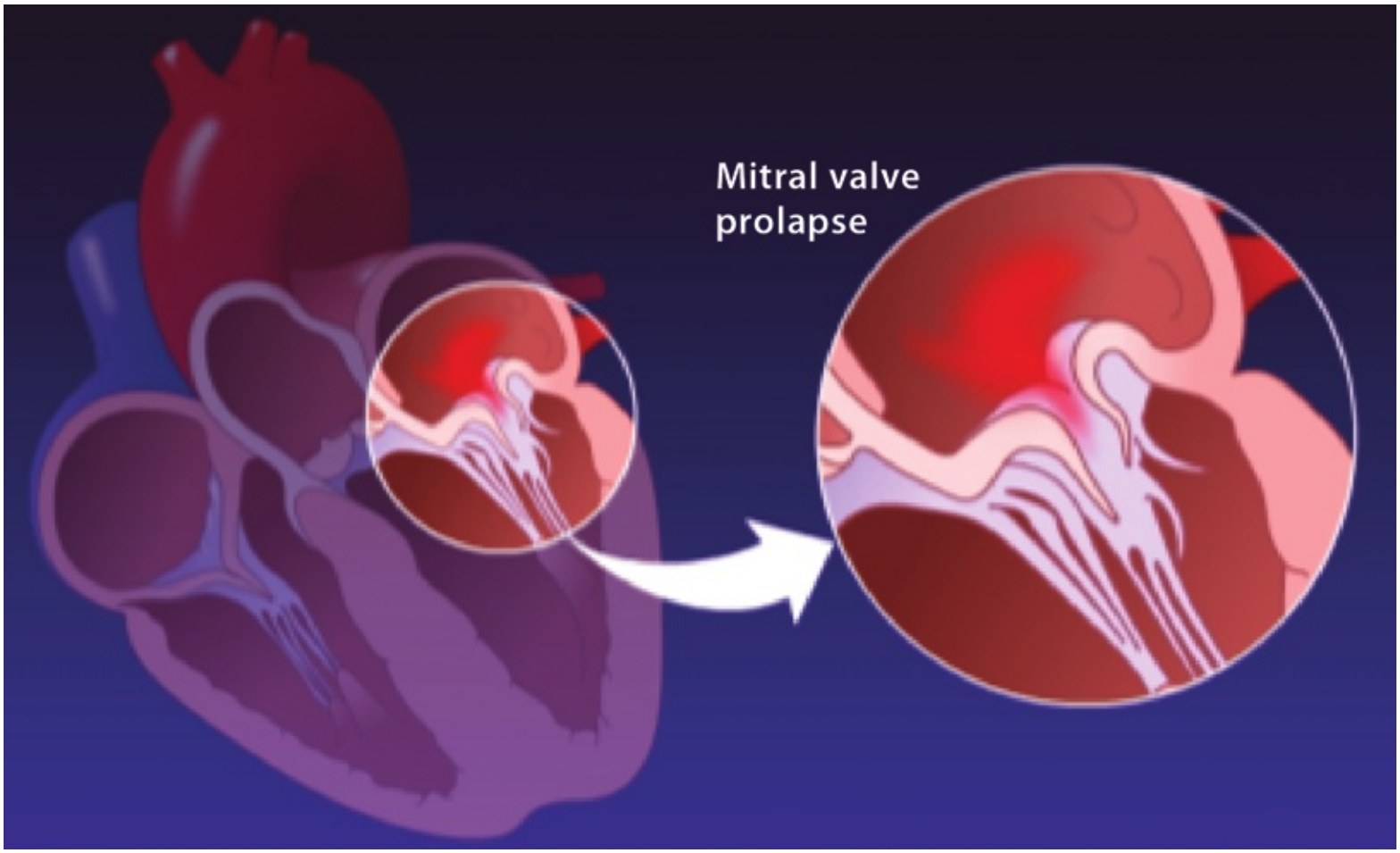
Physical exam

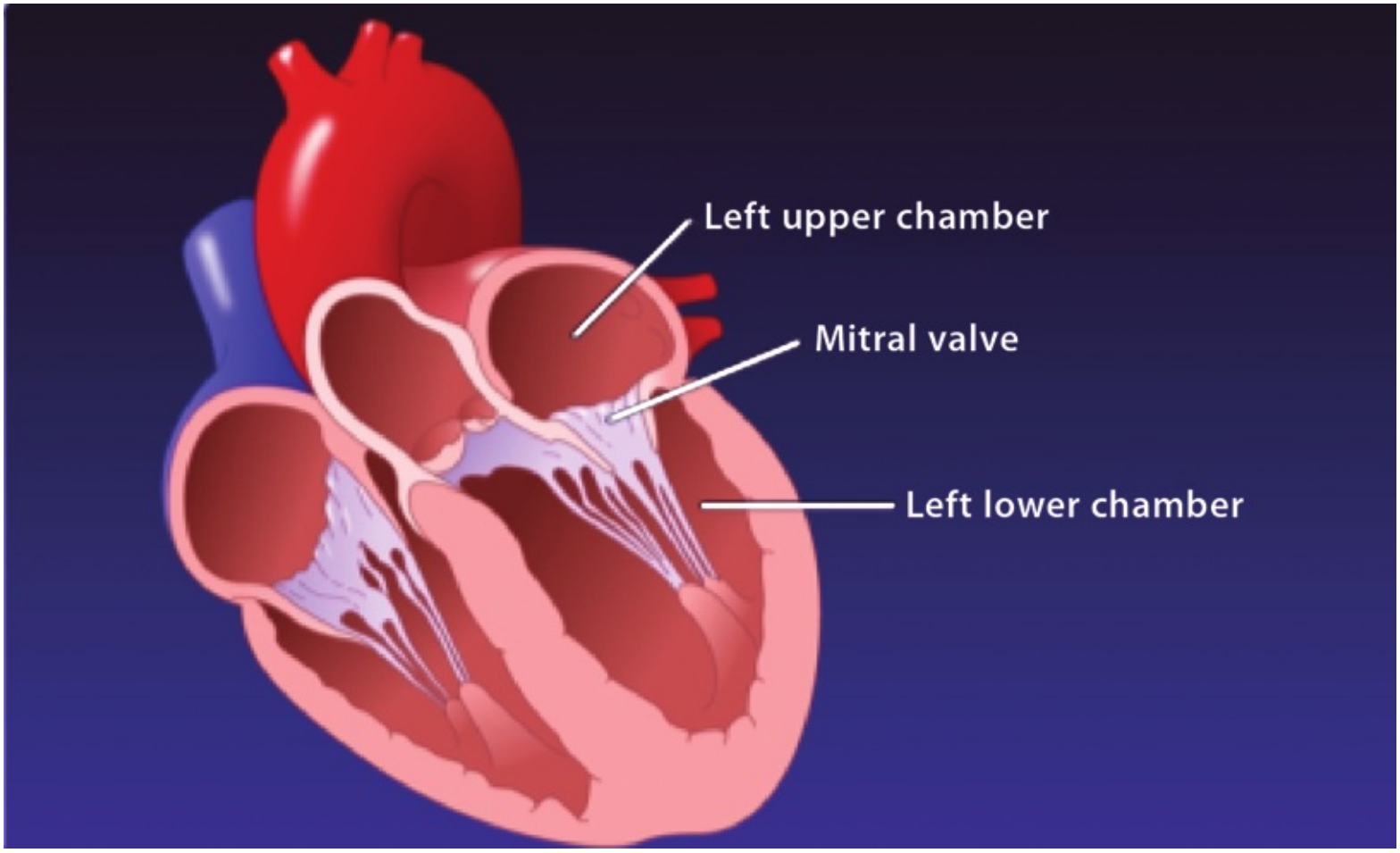
The presence of a heart murmur was confirmed. An echocardiogram revealed the presence of mitral valve prolapse.

Master 3.3

Permission granted for classroom use.







Medical Reference Manual: ***Heart and Circulatory System***

Heart murmur

When doctors use a stethoscope to listen to the heartbeat, they hear a lub-DUB sound made by heart valves opening and closing as blood flows through the heart. The term

“heart murmur” refers to an unusual whooshing sound doctors hear when listening to the heartbeat.

Doctors diagnosis heart murmurs in many children at some point in their lives. Most heart murmurs are harmless and need no treatment. Other heart murmurs are called abnormal and may be associated with defects in the heart that were present at birth.

Mitral valve prolapse

In the condition called mitral valve prolapse, one of the heart’s valves doesn’t work properly. The valve flaps are “floppy” and don’t close properly. This sometimes causes blood to flow backward from its normal direction. This backflow of blood may be associated with shortness of breath or chest pain.

The cause of mitral valve prolapse is not known. Most people with the condition are born with it. It tends to run in families and is associated with connective tissue disorders such as Marfan syndrome.

Figure 1. Mitral valve prolapse.

The mitral valve

is a valve that lies

between the left

upper and lower

chambers of the

heart.

In mitral valve prolapse, the valve

This lack of a tight seal can cause

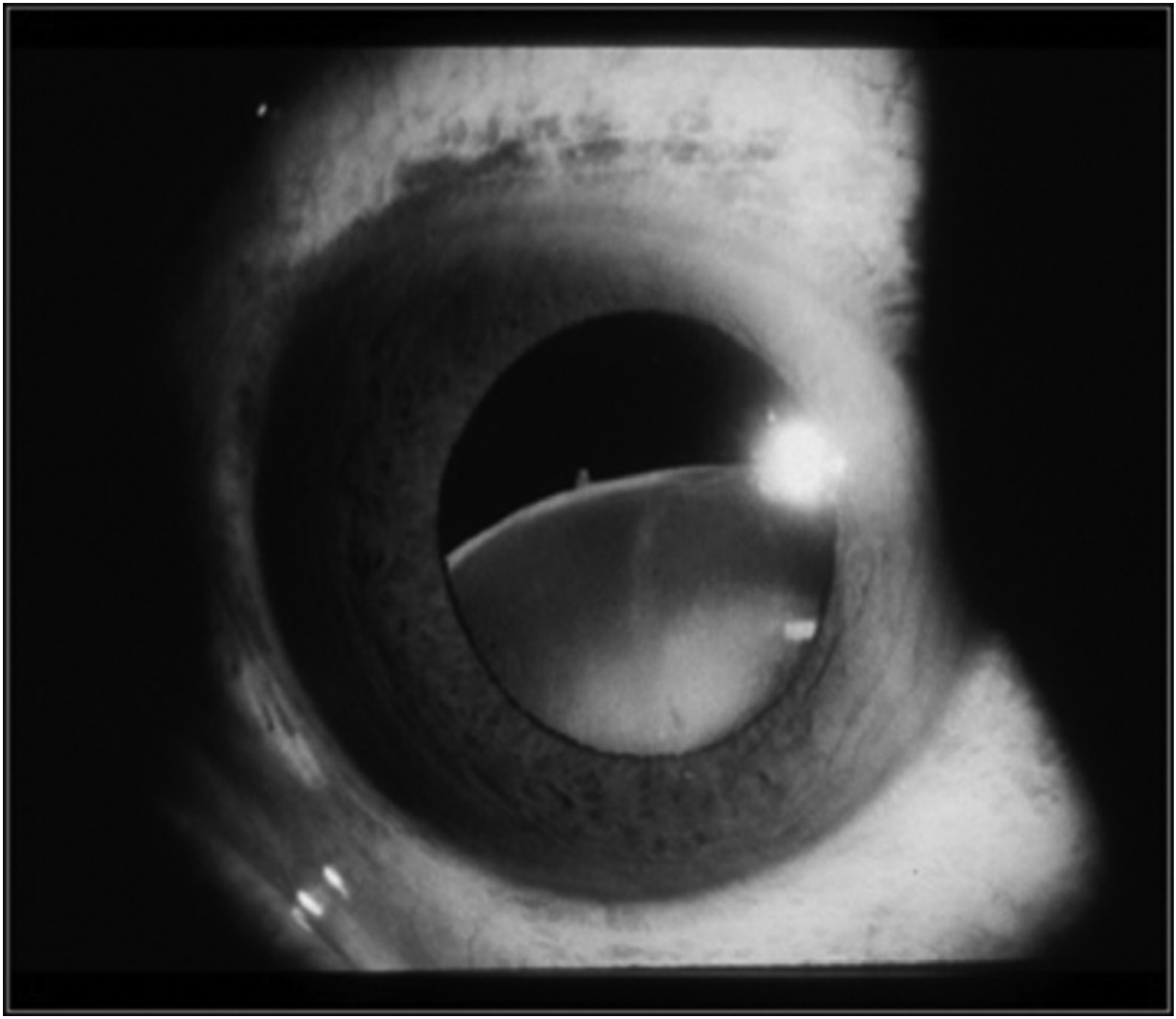
flaps are too large and don’t form a

a small amount of blood to flow

tight seal when they close.

backward, resulting in a heart murmur.

Master 3.3



Vision System

Ophthalmologist Report

Medical history

The patient is myopic (nearsighted). When he was nine years old, he was being fitted for

eyeglasses when an exam revealed that his left lens was dislocated.

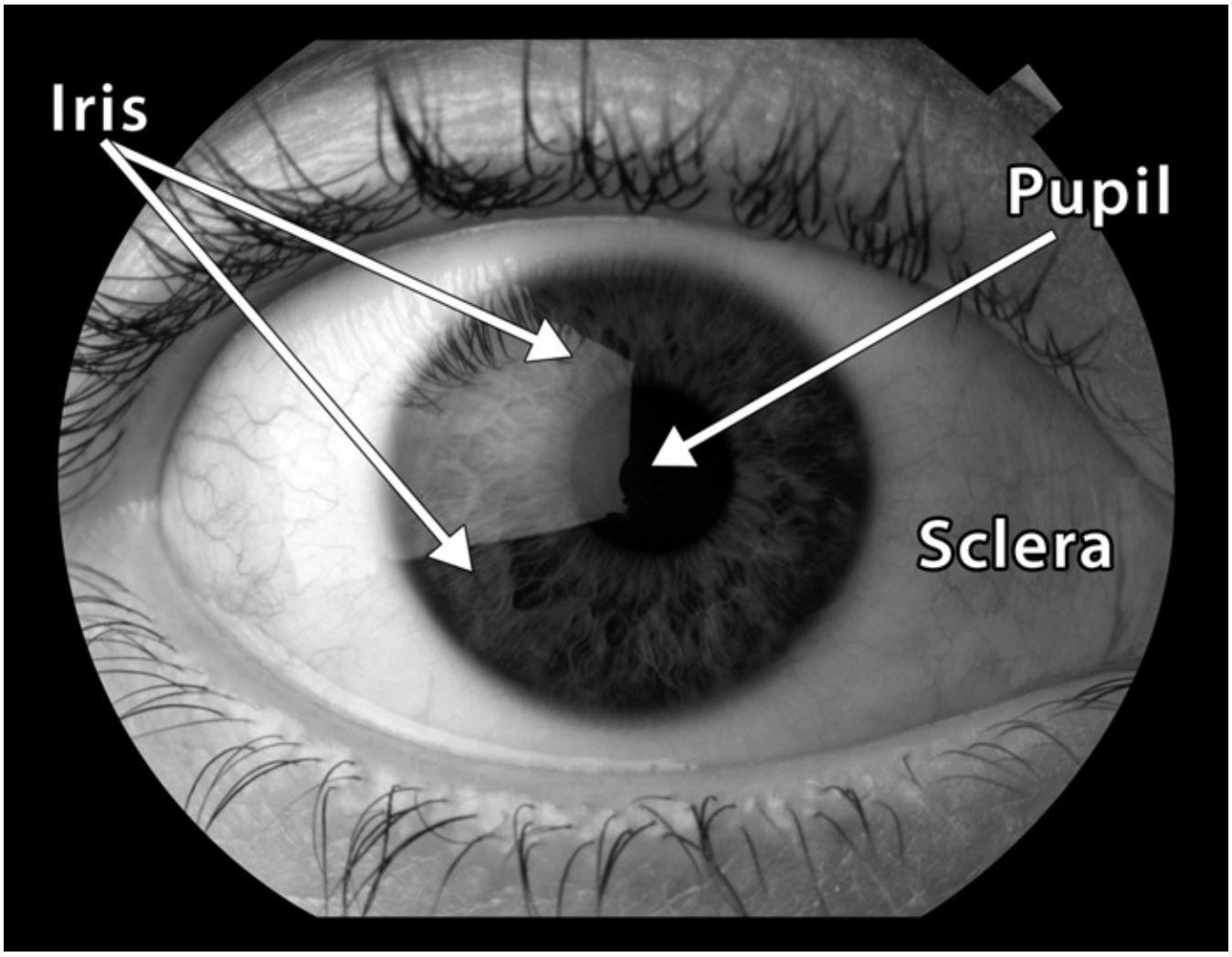
Physical exam

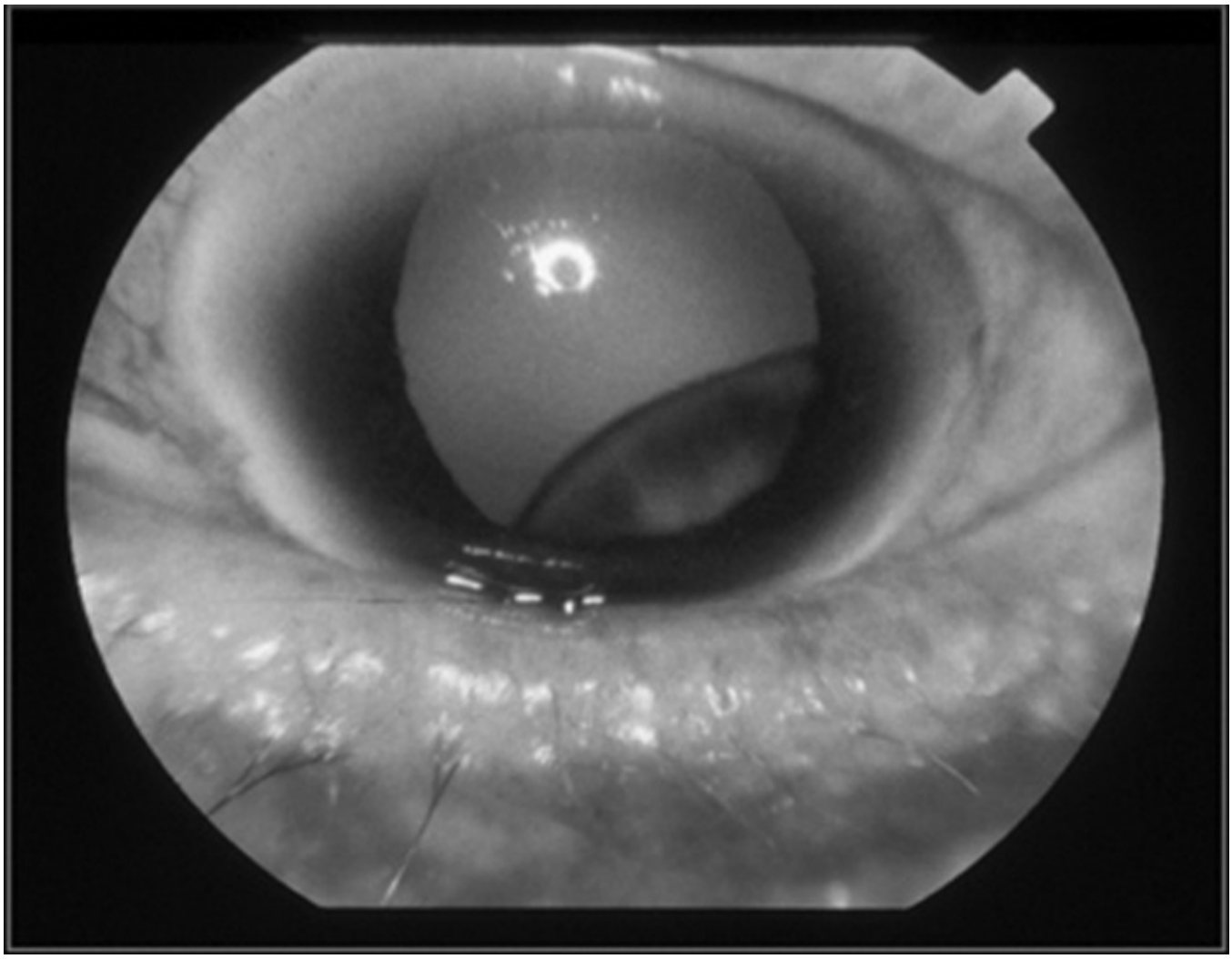
An eye exam confirmed myopia and a repaired detached left lens.

Figure 1. Slit lamp exam: Photo from a slit lamp exam of a patient's eye showing a detached left lens. **(Kevin J. Blinder, MD, The Retina Institute, Washington University School of Medicine)**

Master 3.4

Permission granted for classroom use.





Medical Reference Manual: *Vision System*

Myopia (nearsightedness)

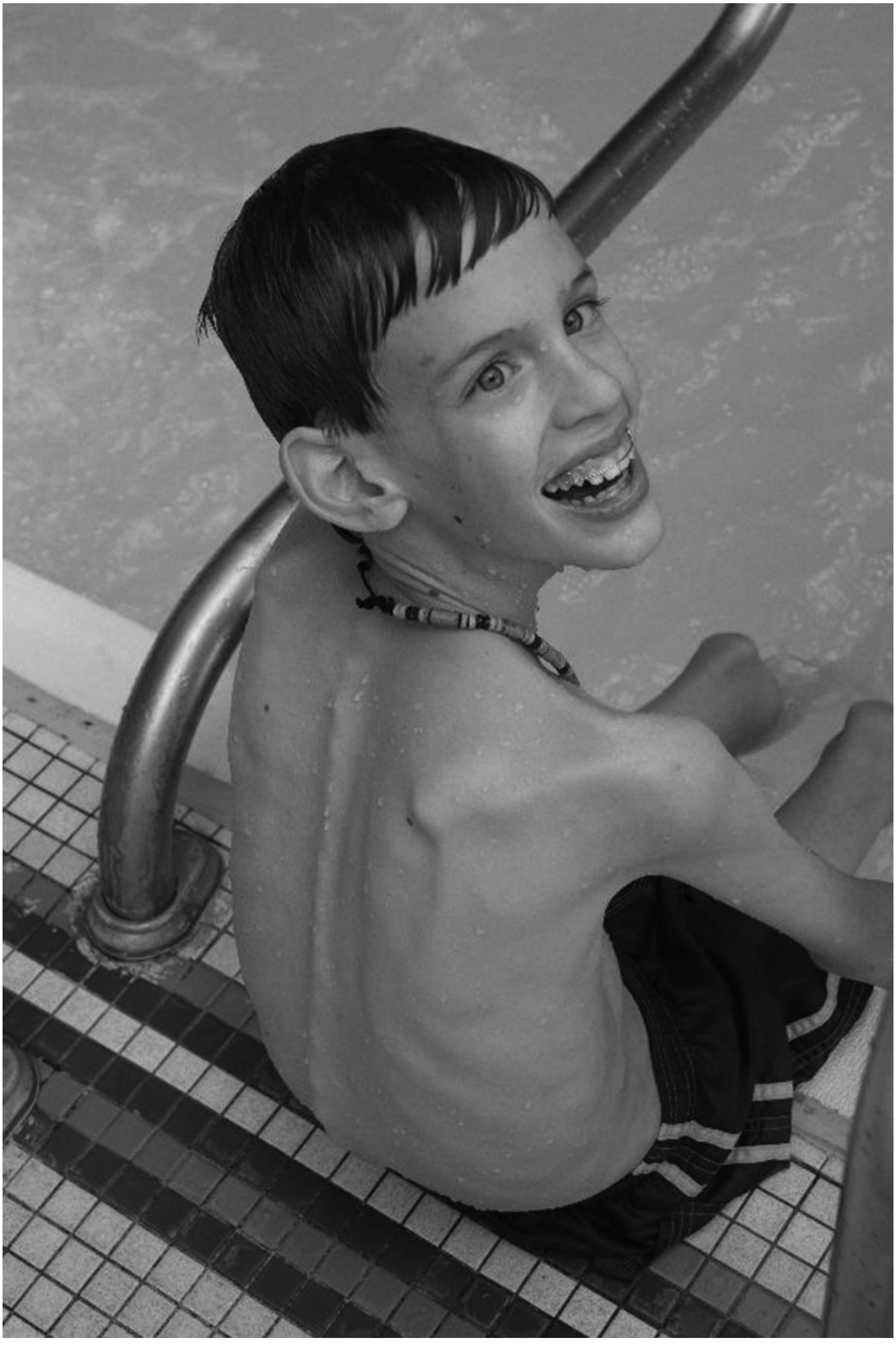
Nearsightedness is caused by a change in the shape of the eyeball so that it is egg shaped instead of round. This egg-shaped eyeball focuses light a little in front of the retina instead of directly on it, resulting in blurry vision. Myopia is a common condition affecting 30 to 40 percent of the American population.

Detached lens

A detached, or dislocated, lens means that the lens has shifted from its normal position (centered behind the pupil). If the dislocation is moderate, the problem may be corrected with glasses. A severe lens dislocation may require surgery to correct.

Detached lenses are rare in the general population. They are often caused by a blow to the eye. The condition is much more common among people with certain diseases involving connective tissue such as Ehlers-Danlos syndrome and Marfan syndrome.

Figure 2. Photos from slit lamp exams: Left, a normal lens; right, a detached lens.



Respiratory System

Pulmonologist Report

Medical history

Patient has been diagnosed with asthma. When seven years old, he experienced a collapsed lung.

Physical exam

Exam confirmed the diagnosis of asthma. Lung volume was normal. Chest X-ray was normal.

Figure 1. Patient photo: Patrick at age 10.

Master 3.5

Permission granted for classroom use.

Medical Reference Manual: *Respiratory System*

Table 1. Information about Asthma

What are the

• Coughing

symptoms of

• Wheezing

asthma?

• Diffi culty breathing

What causes asthma Asthma attacks are a response to environmental triggers attacks?

that leads to

• Infl ammation of the airways. This swelling and irritation

inside the airways leads to diffi culty breathing.

• Bronchospasms. The muscles surrounding the airways

go into spasm, leading to their narrowing.

In rare cases, asthma is associated with disorders of the

connective tissue.

What are the

• Dust

triggers for asthma

• Mold

attacks?

• Pollen

• Pets

• Cigarette smoke

• Pollution

• Illness (infection by bacteria and viruses)

How is asthma

Inhaled drugs, such as albuterol, help widen the airways

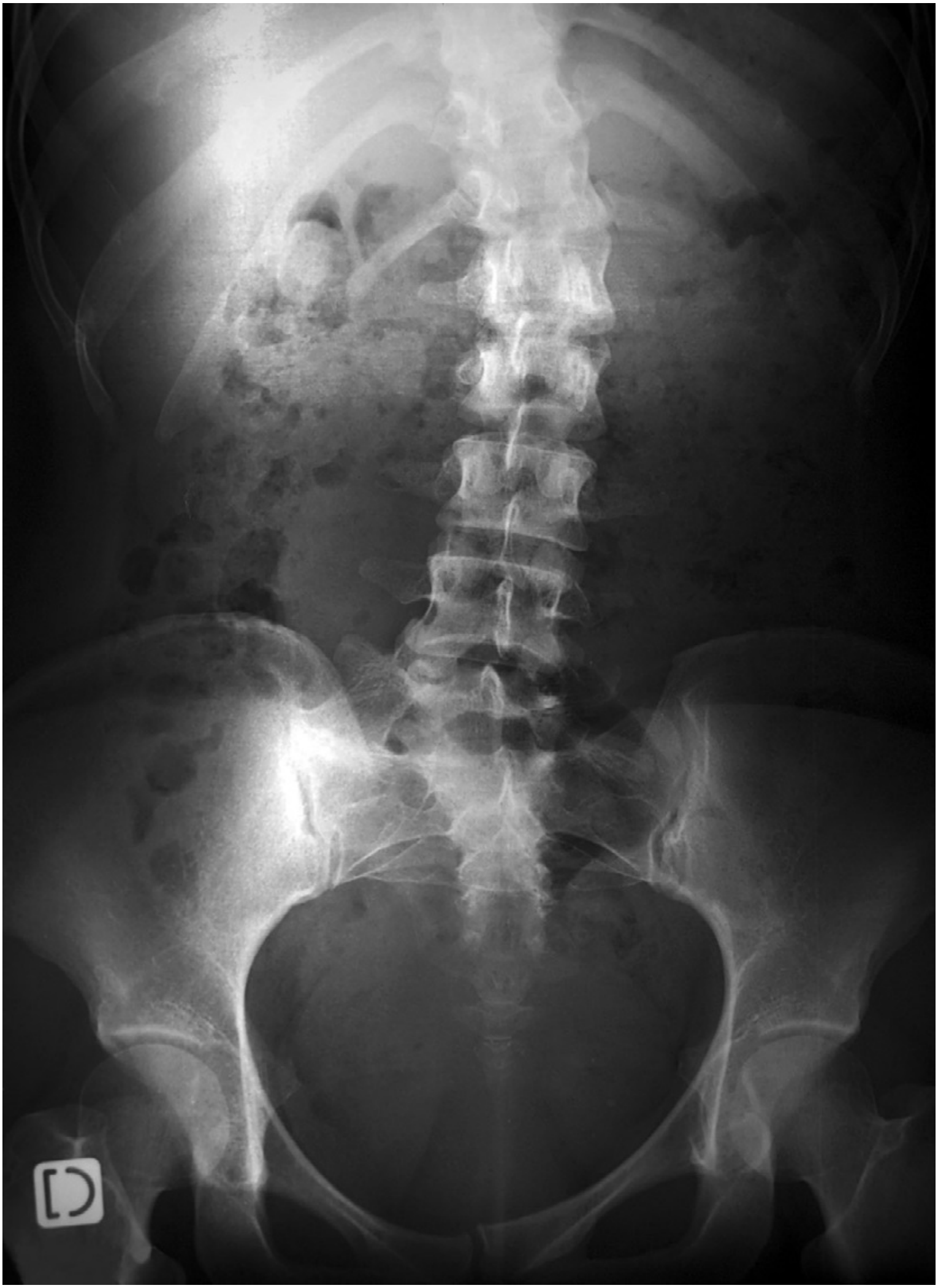
treated?

during asthma attacks and make it easier to breathe.

For long-term management of asthma, inhaled steroids are

safe and can be used every day.

Master 3.5



Skeletal System

Orthopedist Report

Medical history

Patient was previously diagnosed with mild scoliosis (curvature of the spine).

Physical exam

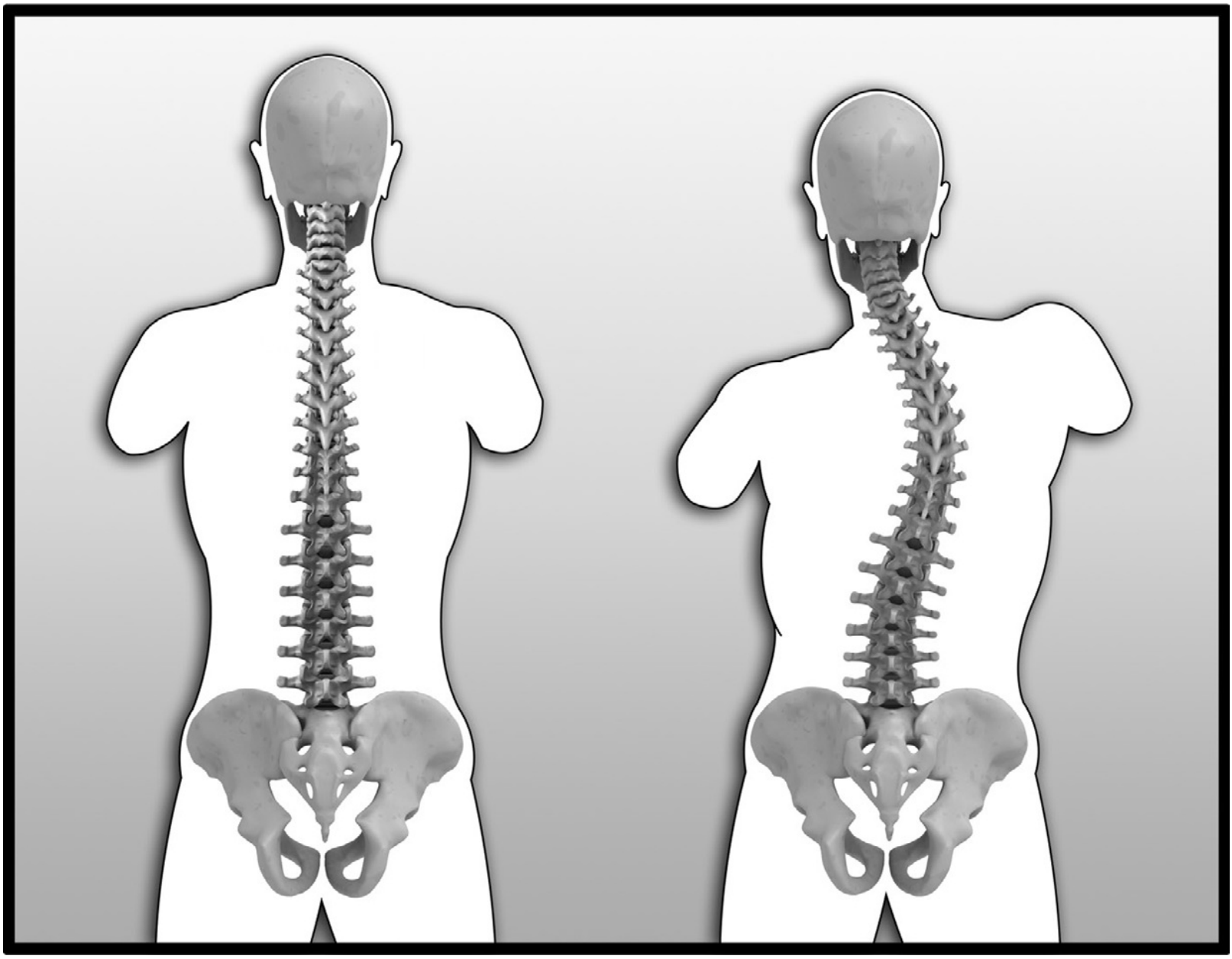
A physical exam and X-rays confirmed the presence of mild scoliosis. The curvature was measured to 15 degrees. It was noted that the patient has unusually long, slender arms, fingers, and feet.

Figure 1. Patient X-ray: X-ray taken when patient was fi ve years old.

(© Ldambies | Dreamstime.com)

Master 3.6

Permission granted for classroom use.



Medical Reference Manual: *Skeletal System*

Scoliosis (curvature of the spine)

Scoliosis refers to an abnormal curvature of the spine. About 10 percent of adolescents show some degree of scoliosis, but less than 1 percent need treatment for the condition. The severity of scoliosis is described by the extent of the curvature.

Table 1. Severity of Scoliosis

Amount of Curvature

Severity

Curvature less than 20 degrees

Mild

Curvature between 20 and 70 degrees Moderate

Curvature greater than 70 degrees

Severe

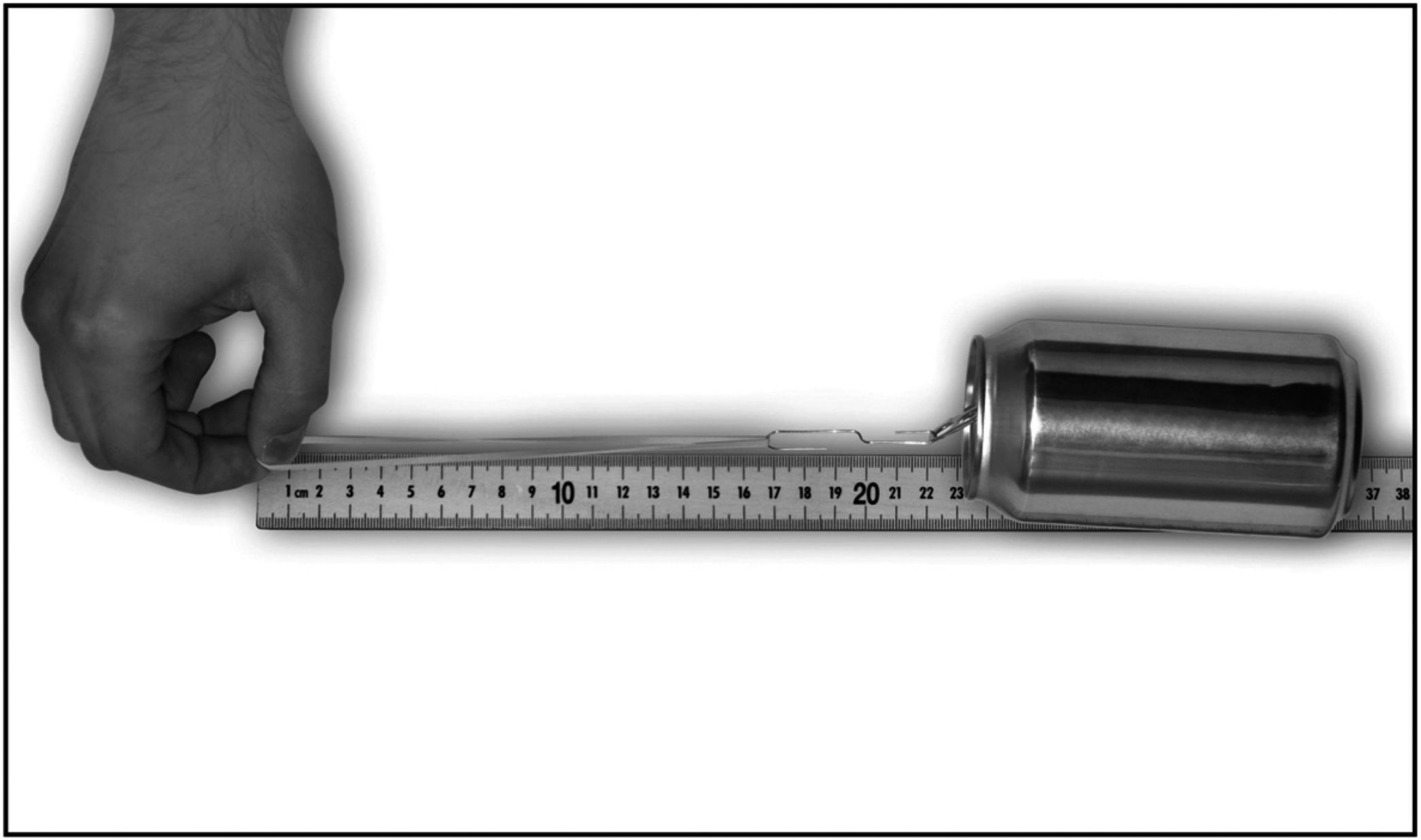
Patients with mild scoliosis usually don’t require treatment beyond examination to see whether the condition worsens. Patients with moderate and severe scoliosis are treated with back braces or surgery.

In most cases, the cause of scoliosis is not known; however, it does seem to run in families. In some cases, the condition is caused by an injury. In other cases, the condition is a result of a muscle, nerve, or connective tissue disease.

Figure 2. The spine and scoliosis: Left, normal spine; right, spine showing scoliosis.

(© Sebastian Kaulitzki | Dreamstime.com)

Master 3.6


1 cm 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 37 38

Measuring Elasticity

Steps for measuring the elasticity of rubber bands

1. Unfold the paper clip into an S shape.

Figure 1. Measuring elasticity.

2. Slip one end of the paper clip through the pulled tab on top of the soda can.

3. Place the other end of the paper clip through the rubber band.

4. Hold a meter stick upright on a hard surface so that the end reading “100 centimeters” is resting on the surface and the end reading “0 centimeters” is up in the air.

5. Hold the top of rubber band (the end away from the paper clip) up to the end of the meter stick that reads “0.”

6. Observe and record in your notebook how far down the meter stick the rubber band has stretched.

7. Repeat Steps 2 through 6 for the second rubber band.

Master 3.7

Diagnosing a Connective Tissue Disorder

Name(s):

1. You will try to match Patrick's medical symptoms to four different disorders of connective tissue.

2. For each of Patrick's symptoms listed in the table under "medical history,"

decide whether that symptom is consistent with each of the four connective tissue disorders written across the top row. Use the information supplied in the Medical Reference Manual.

3. Place a check mark in the appropriate box when the symptom is consistent with the connective tissue disorder.

Table 1. Checklist of Patrick's Symptoms

Patrick's

Ehlers-Danlos

Marfan

Osteogenesis

Scleroderma

medical history

syndrome

syndrome

imperfecta

Myopia

Detached eye

lens

Asthma

Collapsed lung

Heart murmur

Leaky heart valve

Long arms and

legs

Curvature of

spine

Master 3.8

Medical Reference Manual: Disorders of the Connective Tissue

Connective tissues are made of proteins and fats. They support your body's organs and give your tissues their shape. Cartilage is an important connective tissue. It is stiff but more flexible than bone. Cartilage helps your bones move and glide over each other.

It also gives shape to body parts such as your nose and ears.

Connective tissue may be damaged by injury or through an infection. It can also be damaged by a large number of genetic disorders that occur rarely in the population.

A few of them are described below.

Ehlers-Danlos syndrome

Ehlers-Danlos syndrome refers to a collection of related disorders that weaken connective tissues. Symptoms can be mild to life threatening. They include the following:

• heart valves that leak

• weakened blood vessels

• loose joints

• abnormal wound healing

• soft, stretchy skin that bruises easily

• muscle weakness

• joint dislocations

Ehlers-Danlos syndrome is an inherited disorder. Treatment involves managing symptoms and learning how to protect the joints and prevent injuries.

Scleroderma

Scleroderma is a group of related disorders involving abnormal growth of connective tissue. One

type of scleroderma affects only the skin. Another type can also affect other body systems. The cause of scleroderma is not known. It is more common in females than males. Other symptoms may include the following:

• calcium deposits in connective tissues

• narrowing of blood vessels in the hands and feet

• swelling of the esophagus (tube between the throat and stomach)

• thick, tight skin on fi ngers

• red spots on hands and face

Treatment involves managing the symptoms.

Master 3.9

Marfan syndrome

Marfan syndrome is a disorder of connective tissue that is due to mutations in a gene that codes for a connective tissue protein called fibrillin. Symptoms can be mild to severe. Often, people with Marfan syndrome are tall and thin and have loose joints.

Their fingers and feet may be unusually long. Other symptoms may include the following:

• heart valves that leak

• heart murmur

• weakened blood vessels

• curvature of the spine

• fl at feet

• sudden lung collapse, sometimes asthma

• nearsightedness and problems with the eye lens

• stretch marks on the skin

• teeth that are crowded together

Marfan syndrome is an inherited disorder. Treatment involves managing symptoms and adopting physical activity guidelines that are specific to each person.

Osteogenesis imperfecta

Osteogenesis imperfecta is an inherited disorder that causes bone weakness. The disorder is caused by mutations to a gene involved with making the protein collagen.

Sometimes, bones break for no apparent reason. Symptoms can be mild to severe.

Other symptoms may include the following:

• muscle weakness

• curvature of the spine

• loose joints

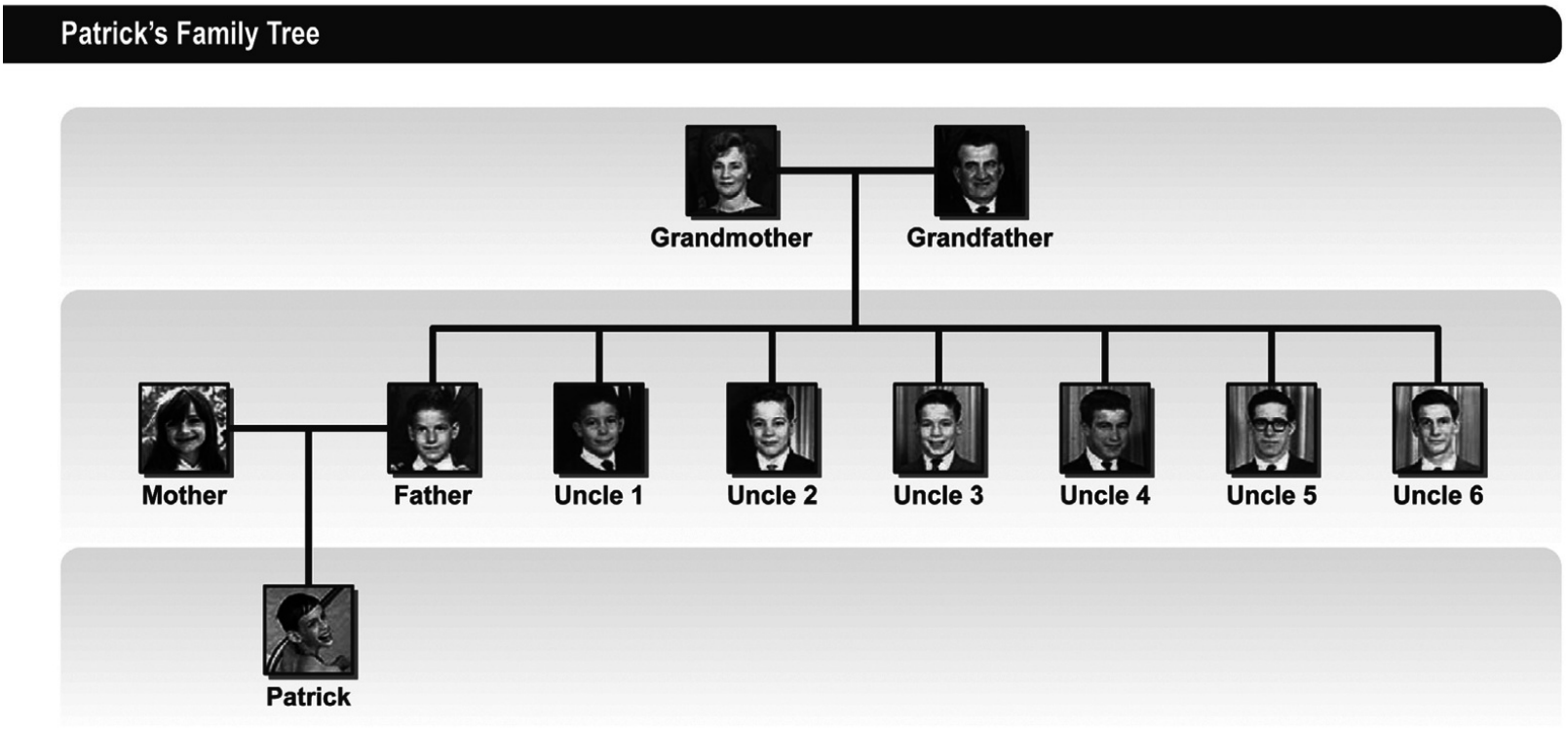
• hearing loss

• skin that bruises easily

• brittle teeth

Treatment involves exercise, physical therapy, braces, and surgery.

Master 3.9



Patrick's Family

Figure 1. Patrick's family on his father's side.

Grandmother: In good health

Grandfather: Died after several heart operations

Mother: In good health

Father: Has had two heart operations and has mild scoliosis

Uncle 1: Died from brain cancer

Uncle 2: In good health

Uncle 3: In good health

Uncle 4: Has had a heart operation and a collapsed lung

Uncle 5: Died after several heart operations and had a detached eye lens Uncle 6: Has type 2 diabetes

Master 3.10

Living with Marfan Syndrome

Questions to a doctor from young people who have Marfan

syndrome

1. “Is there any possible way for the Marfan gene to be detected before a child is born and maybe fi nd a way to prevent it from mutating itself?”

2. “When they measured my heart with the echocardiogram, they told my

mom they don’t think I should do marching band. I was wondering, if I don’t exert myself too much, if I take it at my own pace, do you think I could do it?

Comments from those young people about the most frustrating

part of having Marfan syndrome

1. “The most frustrating thing for me is … I can’t drive. I tried to get my permit, and I couldn’t pass the vision test because I did have my retina detached.”

2. “The thing that frustrates me the most is all the aches and pains in my joints and sternum.”

3. “When it comes to how you’re socially accepted, high school is really lame. In a couple of years, it’s not going to matter what sport you played or anything. It is going to matter what you know and what you do with the

knowledge that you know.”

Master 3.11

Permission granted for classroom use.

Doctor Visits 1 and 2

Background

Jason and Kim are the parents of a five-year old girl, Hanna. They are concerned because she has had flu-like symptoms for three weeks and has not responded to treatment. The family doctor was concerned that something more serious than flu might be responsible for Hanna’s symptoms. He referred Hanna to another doctor for further examination.

First visit

The doctor examined the child and immediately noticed that she had signs of an infection. She felt the child’s abdomen and observed that the liver appeared to be swollen. The doctor asked the parents about their daughter’s health and the health of the rest of the family. Finally, she ordered

some blood tests.

Second visit

During the follow-up visit, the doctor explained that the results of the blood tests showed there was a problem. The doctor explained that Hanna had developed a cancer of the blood called leukemia. Jason and Kim were understandably upset to hear this news. The doctor further explained the nature of the disease and how it would be treated. She told them that childhood leukemia such as Hanna's is treatable. About 80 percent of children with leukemia are cured after treatment.

Master 4.1

Permission granted for classroom use.

Internet Search Results

1. Federal Center for Cancer Research

Information about leukemia, its causes, symptoms, diagnosis, and treatment …

2. My Leukemia Blog

Living with Cancer: Reflections and remembrances of a cancer survivor …

3. The Cancer Research Center at Lincoln State University

Breast cancer, Prostate cancer, Leukemia, Lymphoma, …

4. Information about Leukemia from the American Blood Cancer Society

Cells of the blood, Stem cells and leukemia, White blood cells, bacteria …

5. Leukemia—Medhealthopedia: The Do-It-Yourself Encyclopedia

Leukemia is a form of cancer that is …

6. Cancer drugs for less! Leukemia

Order drugs from overseas to treat leukemia and save!

7. Fed approves new drug to treat leukemia

Medical Business Weekly (Washington, DC)—The Food and Drug

Administration today approved Hamilton Pharmaceutical's drug Arresta for the treatment of leukemia …

8. Leukemia: Defi nition from medicaljargon.com

Leukemia—A cancer of the white blood cells. White blood cells …

Master 4.2

Evaluating Internet Search Results

Name(s):

Questions

1. Hanna's parents searched the Internet because they wanted to fi nd information about childhood leukemia. They wanted to answer such questions as

• What causes leukemia?

• What are its symptoms?

• How is it diagnosed?

• How is it treated?

• How likely is it that the treatment will help?

2. When thinking about the results of an Internet search, for each hit, ask yourself:

• Is this site likely to contain the information that I want?

• Is this site likely to contain information that is accurate?

3. The Internet search returned the eight hits on your handout. Rank each hit in the table below by placing its number in one of the boxes. The most helpful hit is on the left side, and the least helpful hit is on the right side.

Table 1. Ranking the Hits

Most helpful

Least helpful

Master 4.3

Summarizing Information about Leukemia

Name(s):

Federal Center for Cancer Research

Disease definition

Disease symptoms

Disease diagnosis

American Blood Cancer Society

• List types and functions of blood cells.

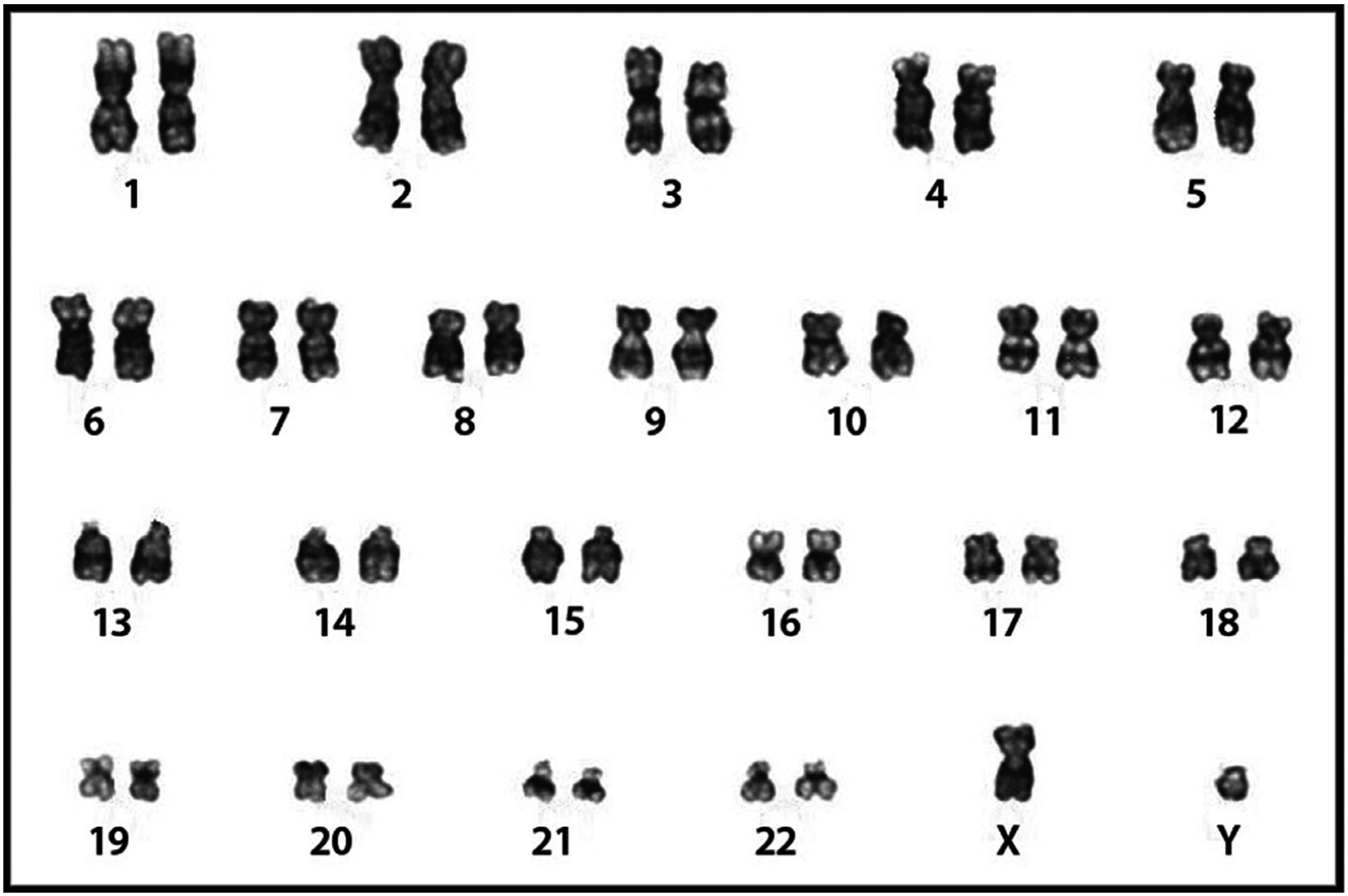
• Where are blood cells made?

• What is a stem cell?

• What is the relationship between stem cells and leukemia?

• Why are people with leukemia more likely to get bacterial infections?

Master 4.4



Karyotype

A karyotype is a photograph of a person's complete set of chromosomes.

A healthy human karyotype shows 22 pairs of numbered chromosomes (arranged by size), where one member of each pair comes from the mother and the other comes from the father.

There is an additional pair called the sex chromosomes. An individual with one X

chromosome and one Y chromosome is male. Someone with two X chromosomes and no Y chromosome is female.

What is the sex of the person whose karyotype is above?

Figure 1. Sample karyotype. **(Genetics Department, Affi liated Laboratories, Inc., Bangor, Maine.)**

Master 4.5

Another Doctor Visit

Jason and Kim returned to the doctor's office with Hanna to discuss her treatment. The doctor suggested having Hanna participate in something called a clinical trial. She explained that a clinical trial is a process in which groups of patients receive treatments that differ in one feature of their treatment.

Jason and Kim were alarmed at this suggestion. They asked,

• "Does this mean that you don't know what to do for her?"

• "Do you mean that Hanna may receive a sugar pill instead of a real drug?"

The doctor replied that for decades, most children with leukemia have

participated in clinical trials. The results from these clinical trials have helped greatly improve survival rates. The doctor further explained that, during a clinical trial, patients are never given a sugar pill because effective treatment options are available. Instead, a control group of patients receives the standard therapy while another group of patients receives some experimental treatment.

Master 4.6

Treating Leukemia

Treatments for childhood leukemia in 1970

Standard treatment: Chemotherapy

The standard treatment for childhood leukemia uses three drugs taken together.

This combination of drugs and their doses have been guided by the results of many clinical trials:

• Drug A is prednisone. Cells have the ability to kill themselves if they become damaged. This helps keeps the body free of unhealthy cells. Prednisone works by helping the body kill damaged white blood cells.

Side effects: Increased appetite, indigestion, and nervousness

• Drug B is vincristine. When cells divide, each new cell must receive an identical set of chromosomes. Vincristine interferes with this process and stops white blood cells from dividing.

Side effects: Hair loss, constipation, and nerve damage

• Drug C is methotrexate. When cells divide, they need to make more DNA, RNA, and protein molecules. Cancer cells are dividing rapidly compared with normal cells. Methotrexate interferes with the ability of all cells to make DNA, RNA, and proteins.

Side effects: Stomach pain, shortness of breath, and blood in urine

Central nervous system treatment

Doctors observed that often after chemotherapy treatment was stopped, leukemia reappeared in the central nervous system (brain and spinal cord). To kill cancer cells

“hiding” in this part of the body, the patient’s head is exposed to X-rays and the drug methotrexate is injected directly into the spinal fluid.

Side effects: Learning problems and increased risk for heart disease

Master 4.7

Designing a Clinical Trial

Name(s):

Clinical trial design

Drug A

Drug B

Drug C

Decrease

Decrease

Decrease

Standard dose

Standard dose

Standard dose

Increase

Increase

Increase

Central nervous system treatment

Yes

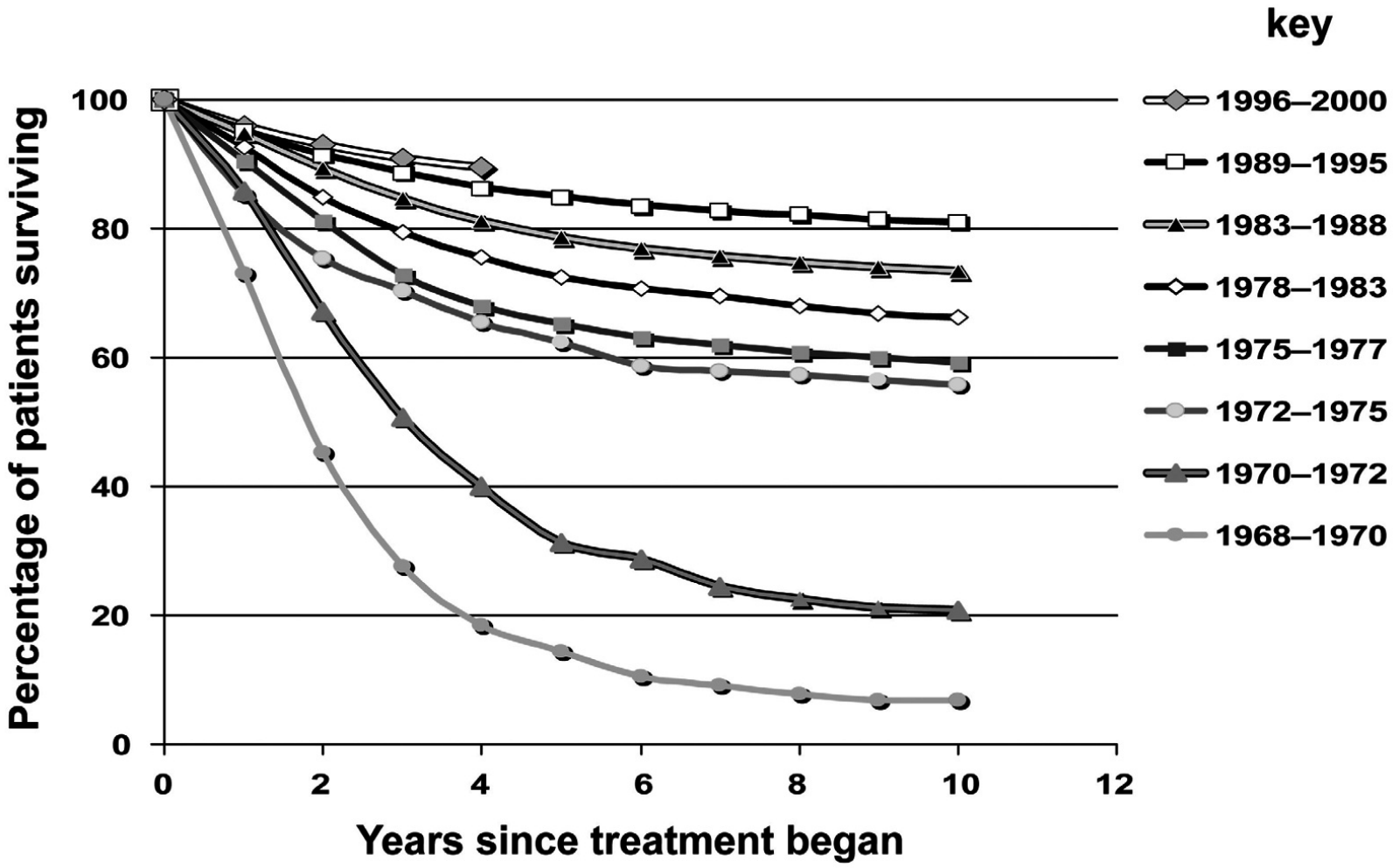
No

Clinical trial results

Conclusion from the clinical trial

Master 4.8

Permission granted for classroom use.



Survival Rates for Children with Leukemia

Image courtesy of Dr. Timothy Garrington

Master 4.9

Permission granted for classroom use.

Information about Leukemia

Federal Center for Cancer Research

Leukemia: A cancer of the white blood cells. White blood cells associated with leukemia are abnormal, and they are produced in very high numbers. Although it is a rare disease, leukemia can affect both children and adults. One type of the disease can appear in a short period of time (days to weeks), while another type of the disease develops more slowly.

Disease symptoms catalog

Leukemia

• Too few red blood cells and platelets

• Repeated infections by viruses and bacteria

• Pain in the joints

• Pain in the abdomen

• Wheezing and coughing

Diagnosing leukemia

Diagnosis of leukemia begins with a physical examination of the patient.

The doctor will

• look for signs of infection, such as runny nose, fever, and cough;

• feel the abdomen to see if the liver or spleen is enlarged;

• take a medical history that involves questions about

– patient

symptoms,

– family health, and

– medications and allergies; and

• order blood tests to measure the numbers of white blood cells, red blood cells, and platelets.

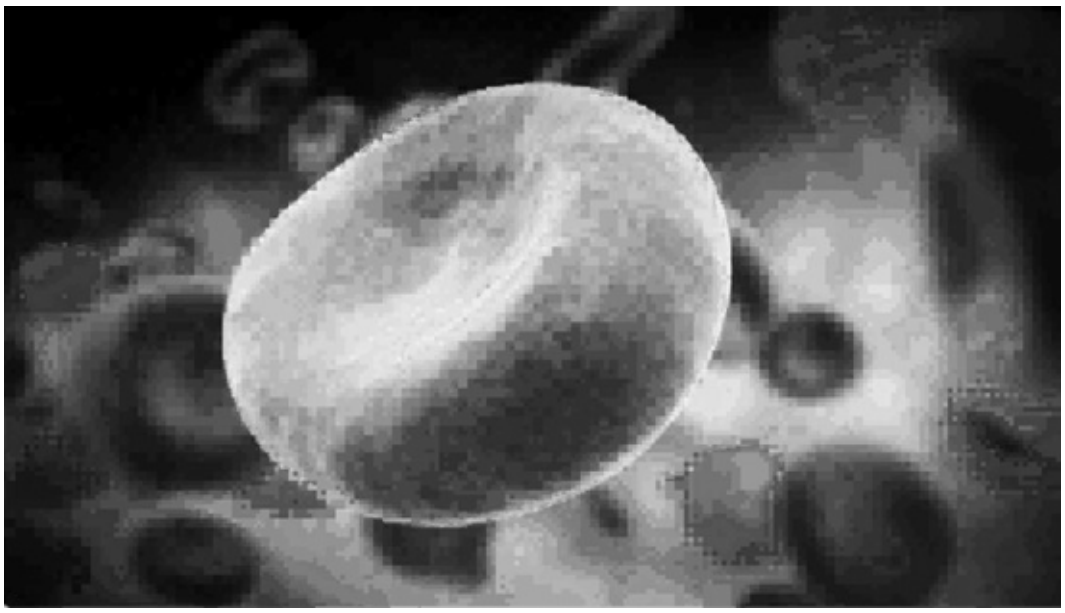
If the physical exam and blood test results suggest the possibility of leukemia, then the doctor may order the following tests:

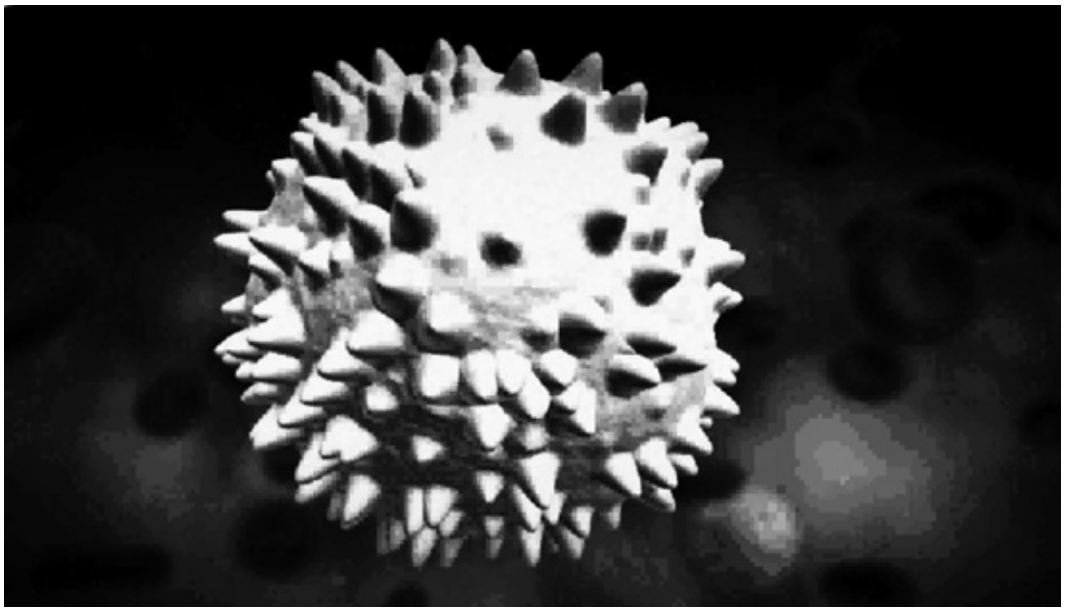
• Bone marrow biopsy: A piece of bone marrow is taken from the back of the hip and checked for the presence of abnormal cells.

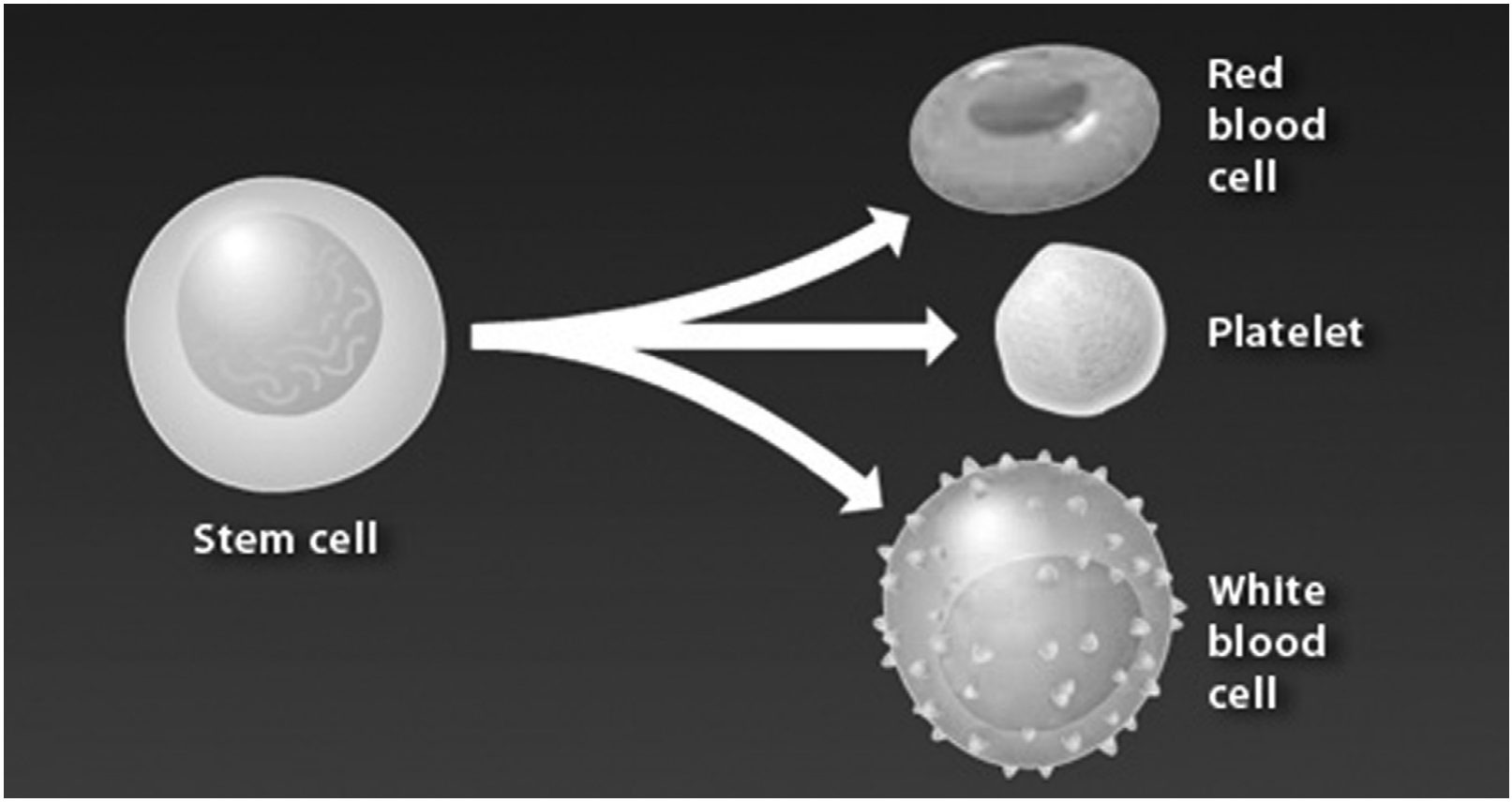
• Lymph node biopsy: As with the bone marrow biopsy, a sample is examined for the presence of abnormal white cells. (Lymph nodes are found throughout the body and help trap and destroy viruses and bacteria.)

• Lumbar puncture (spinal tap): A sample of spinal fl uid is removed and checked for the presence of abnormal cells. The presence of abnormal cells can indicate that leukemia has spread to the central nervous system.

Master 4.10







American Blood Cancer Society

As an adult, your body will contain about 10 pints of blood. This precious fluid flows through thousands of miles of veins, arteries, and capillaries. Let's take a look at the three most-common types of cells found in the blood. First are the red blood cells.

They transport oxygen and nutrients to the body's cells. Second are the platelets. They help stop bleeding and repair wounds. Last, the white blood cells help protect against infection by viruses and bacteria.

Figure 1. Red blood cell.

Figure 2. Platelet.

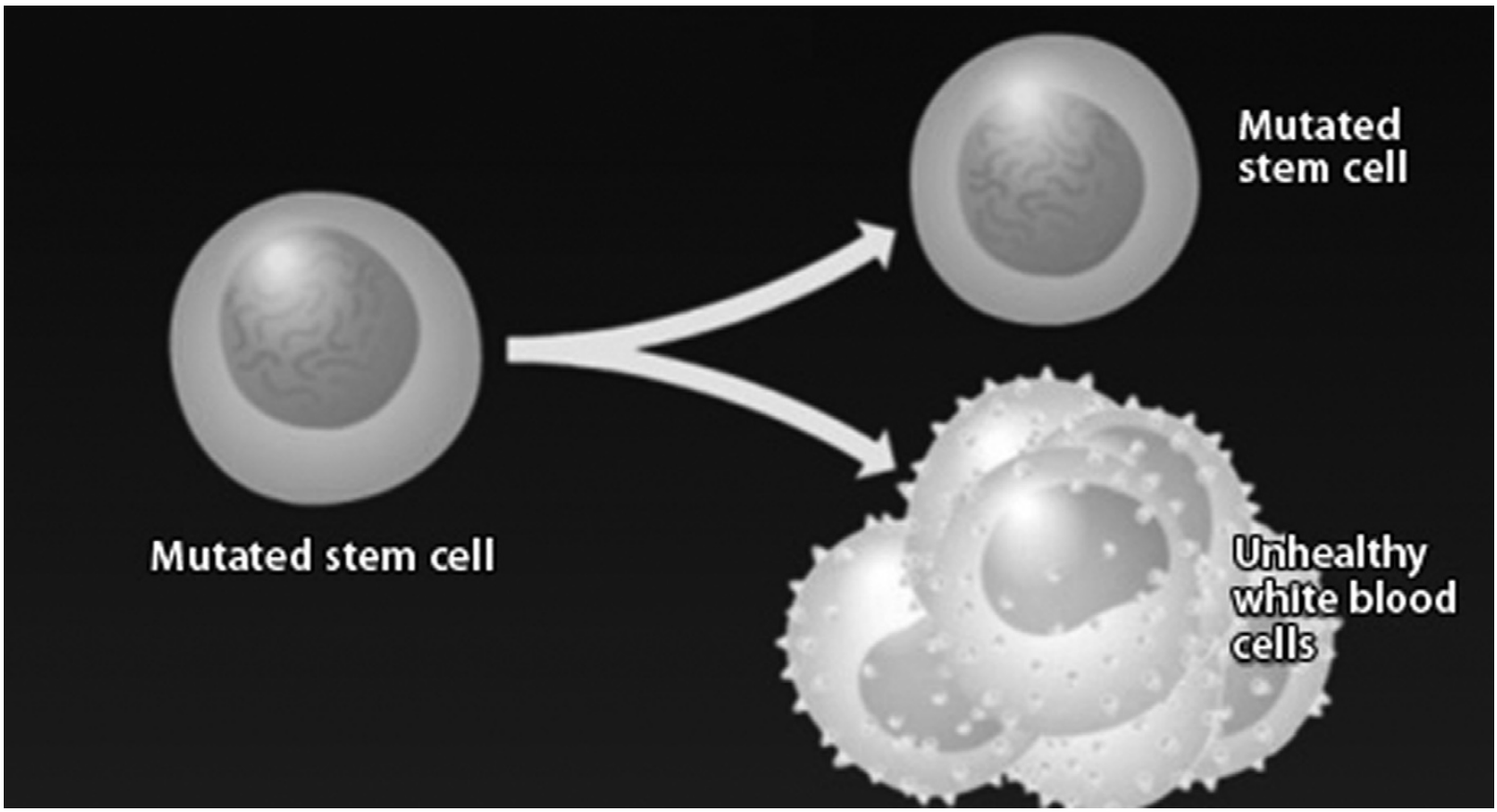
Figure 3. White blood cell.

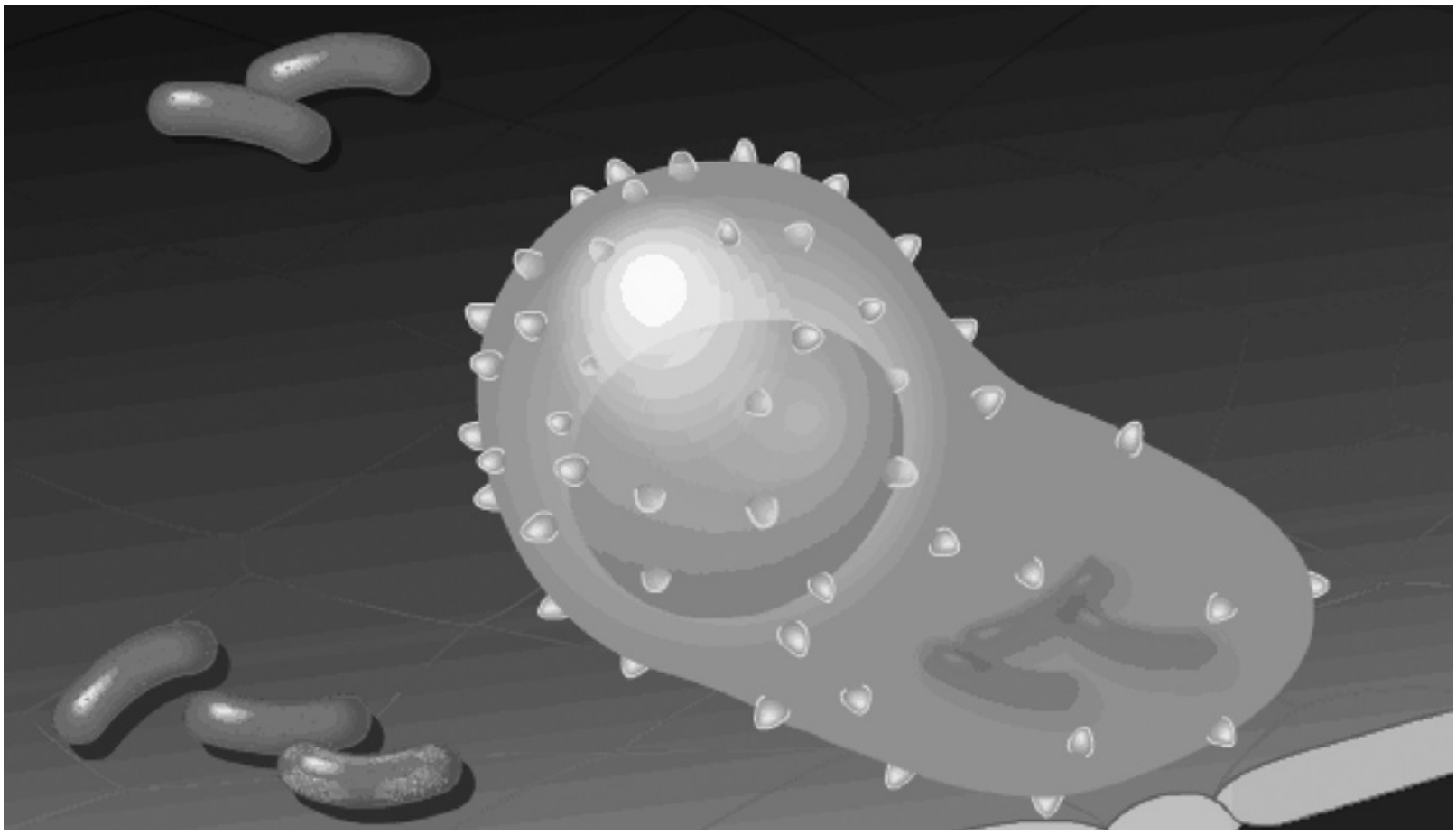
Red blood cells, platelets, and white blood cells are not made in the blood itself.

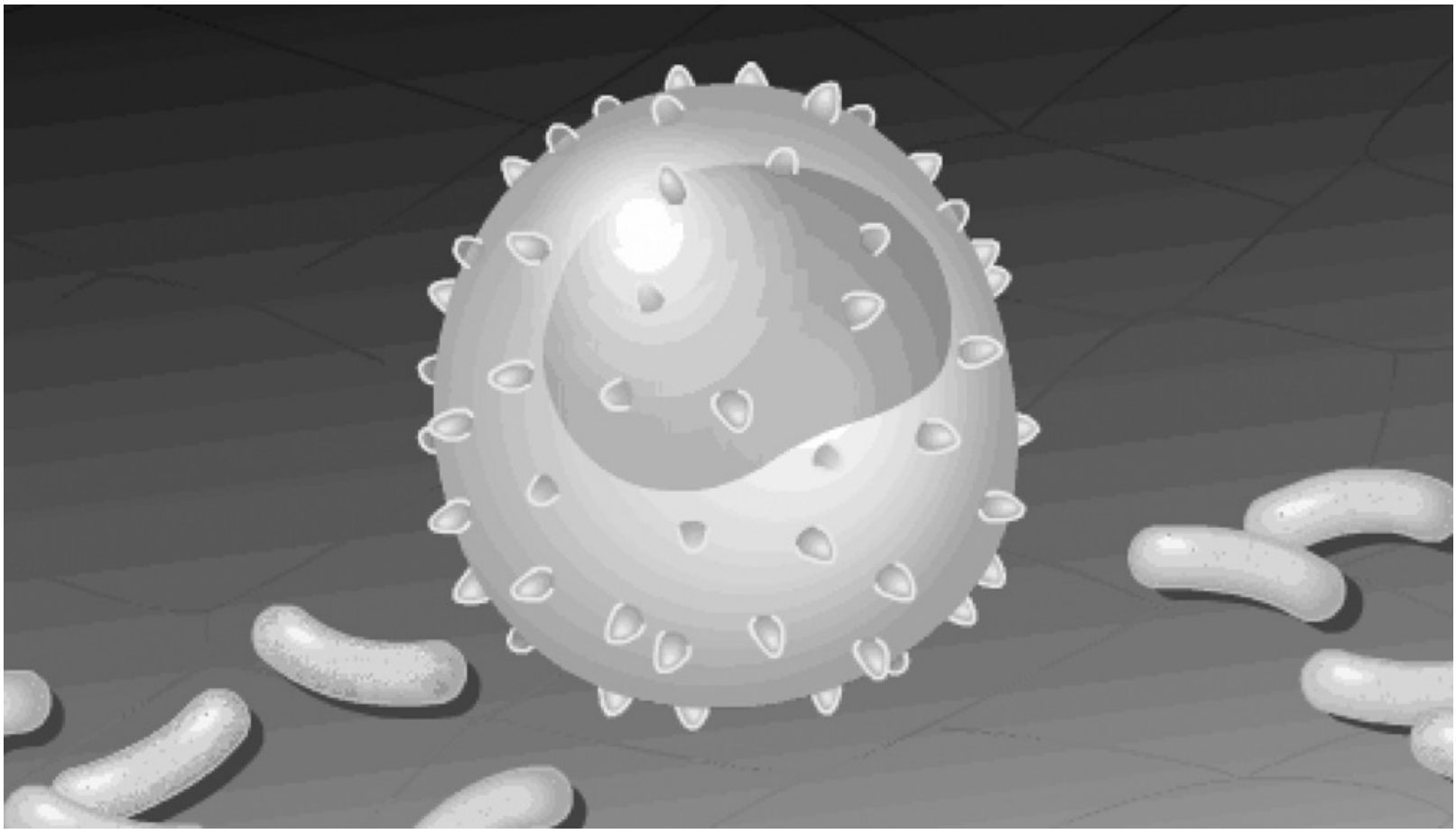
Instead, they are made in a spongy tissue called bone marrow found in the hollow portions of bones. The bone marrow produces cells called stem cells. The stem cells can divide to form red blood cells, platelets, and white blood cells, which enter the bloodstream, where they do their work.

Figure 4. A stem cell in the bone marrow can produce a red blood cell, a platelet, or a white blood cell.

Master 4.10







American Blood Cancer Society (continued)

Leukemia and stem cells

In leukemia, a stem cell becomes mutated and begins to produce unhealthy white blood cells in large numbers. Leukemia is a cancer of the stem cells that are responsible for making white blood cells. As a result, unhealthy white blood cells are produced in great numbers and crowd out the healthy white blood cells. This also causes fewer red blood cells and platelets to be made. When healthy white blood cells encounter bacteria in the blood, they engulf and destroy them. But unhealthy white blood cells produced due to leukemia are not able to attack and destroy invading bacteria.

Figure 1. A mutated stem cell produces another mutated stem cell as well many unhealthy white blood cells.

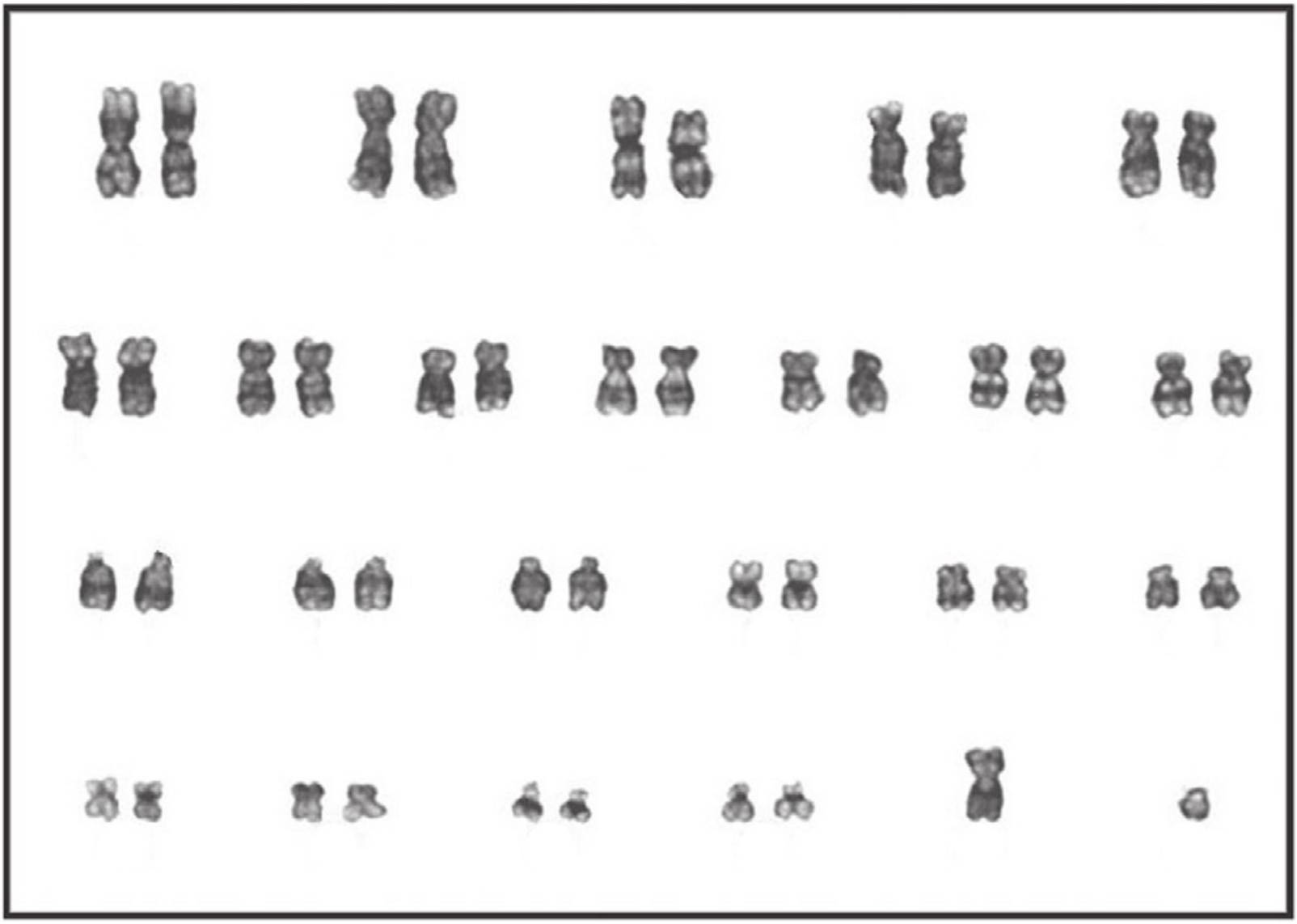
Figure 2. Healthy white blood cells engulf

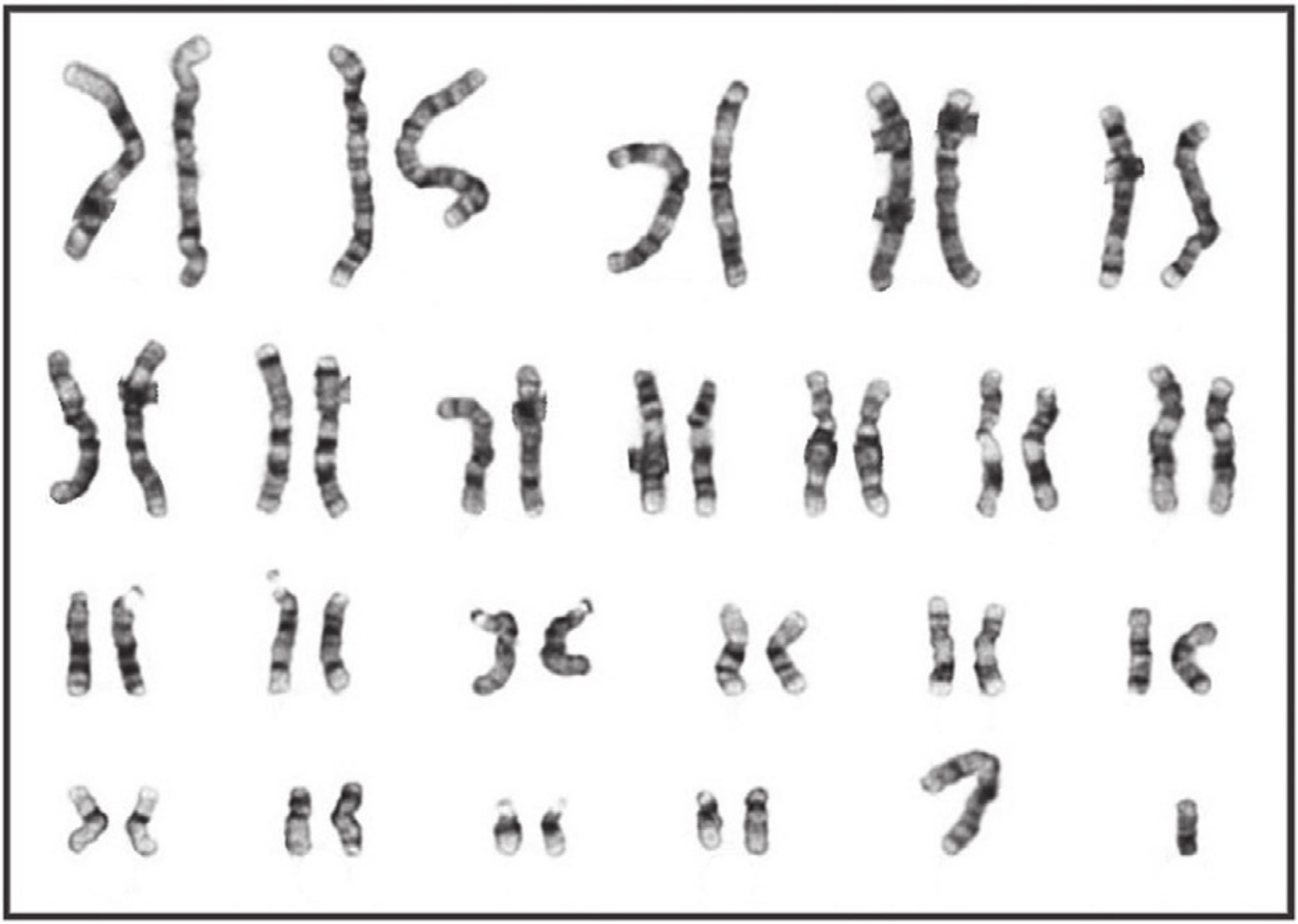
Figure 3. Unhealthy white blood cells do not

and destroy bacteria.

engulf bacteria.

Master 4.10





Family Karyotypes

Figure 1. Hanna. **(Genetics Department, Affi liated**

Figure 2. Kim. **(Genetics Department, Affi liated**

Laboratories, Inc., Bangor, Maine)

Laboratories, Inc., Bangor, Maine)

1

2

3

4

5

1

2

3

4

5

6

7

8

9

10

11

12

6

7

8

9

10

11

12

13

14

15

16

17

18

13

14

15

16

17

18

19

20

21

22

X

Y

19

20

21

22

X

Y

Figure 3. Rick. **(Genetics Department, Affi liated**

Figure 4. Jason. **(Genetics Department, Affi liated**

Laboratories, Inc., Bangor, Maine)

Laboratories, Inc., Bangor, Maine)

1

2

3

4

5

1

2

3

4

5

6

7

8

9

10

11

12

6

7

8

9

10

11

12

13

14

15

16

17

18

13

14

15

16

17

18

19

20

21

22

X

Y

19

20

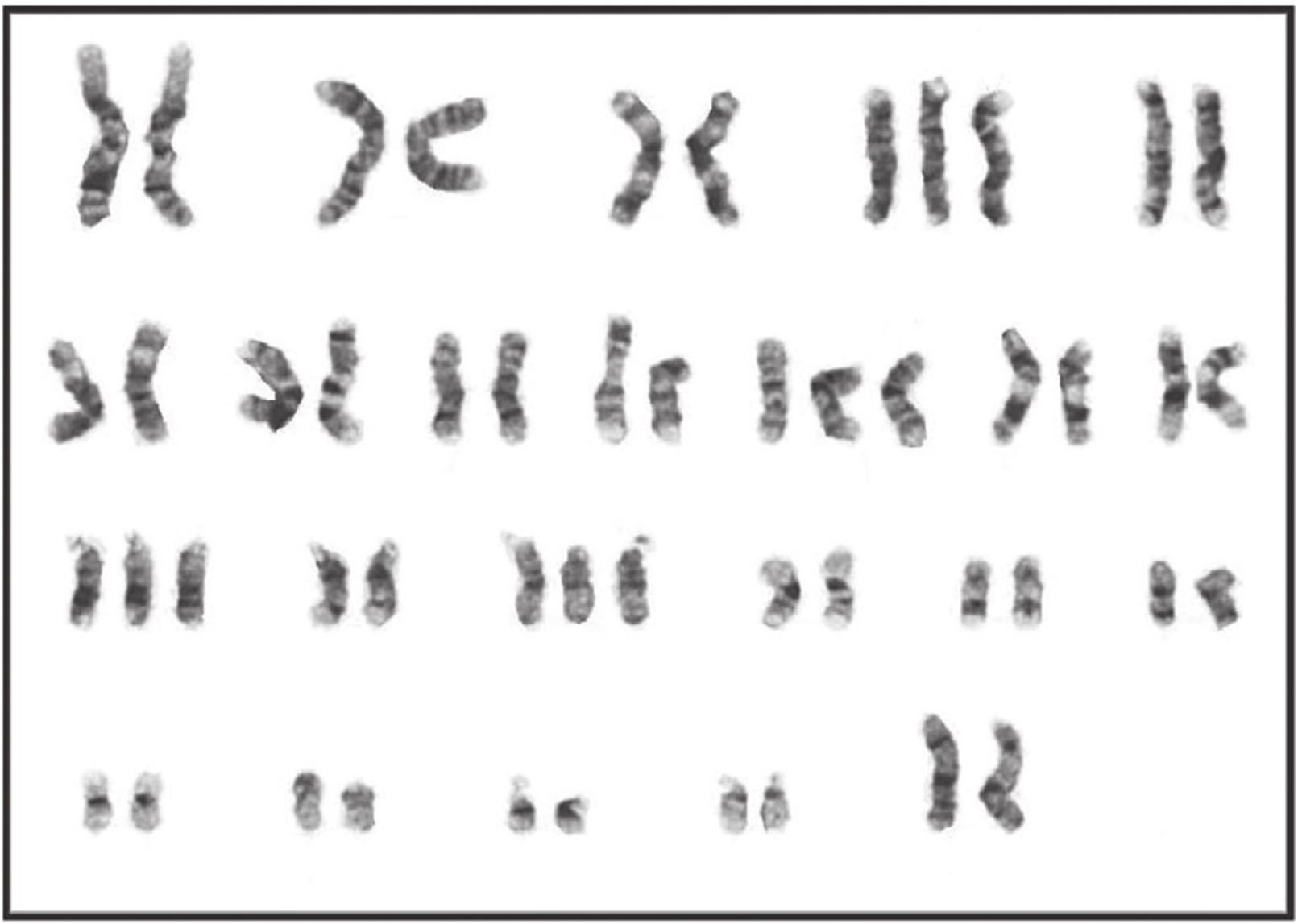
21

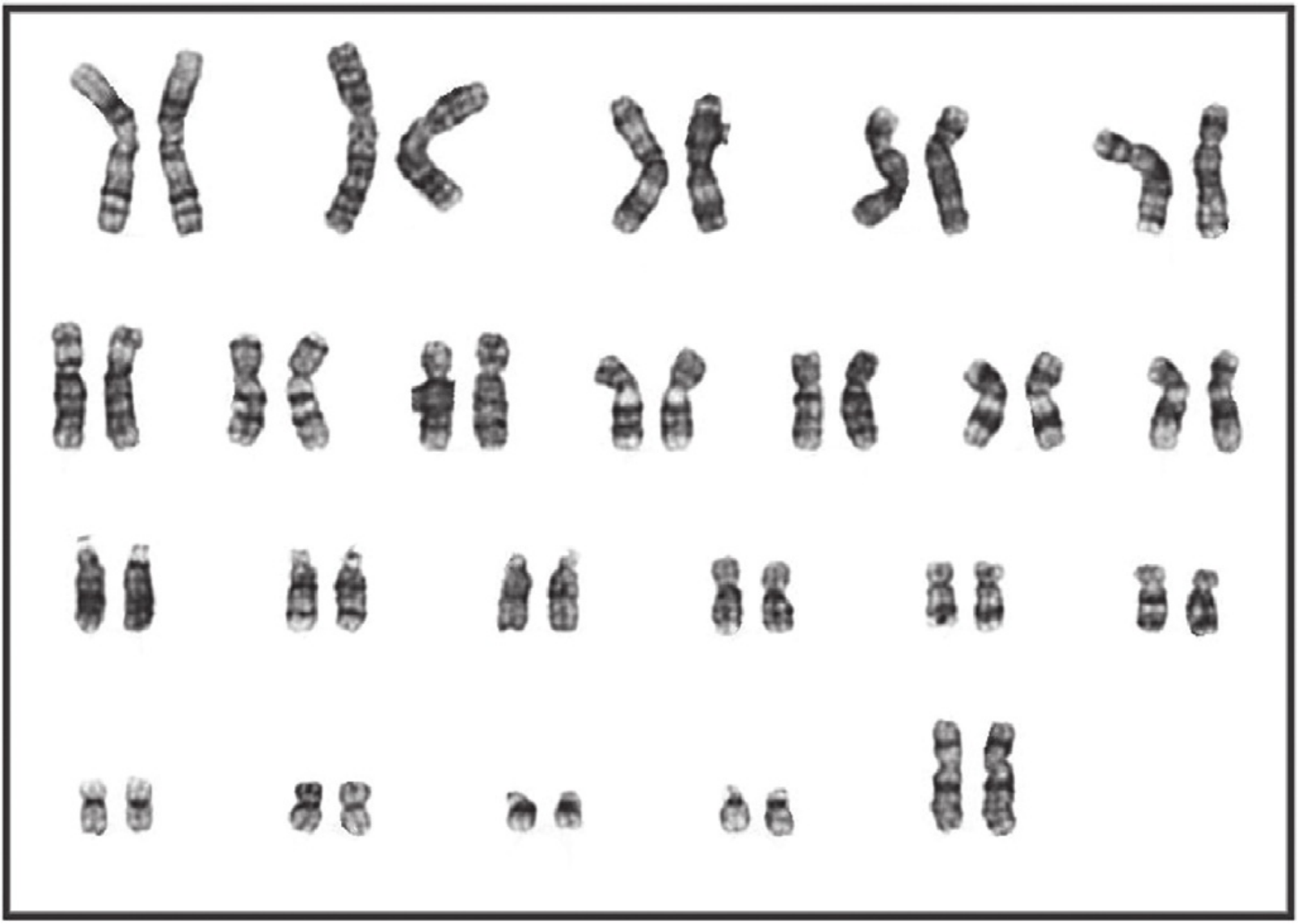
22

X

Y

Master 4.11





Hanna’s Karyotypes

Figure 1. Hanna’s blood cells. **(Genetics Department, Affi liated Laboratories, Inc., Bangor, Maine) 1**

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

X

Y

Figure 2. Hanna's hair follicle cells. **(Genetics Department, Affi liated Laboratories, Inc., Bangor, Maine) 1**

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

X

Y

Figure 3. Hanna's cheek cells. **(Genetics Department, Affi liated Laboratories, Inc., Bangor, Maine) 1**

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

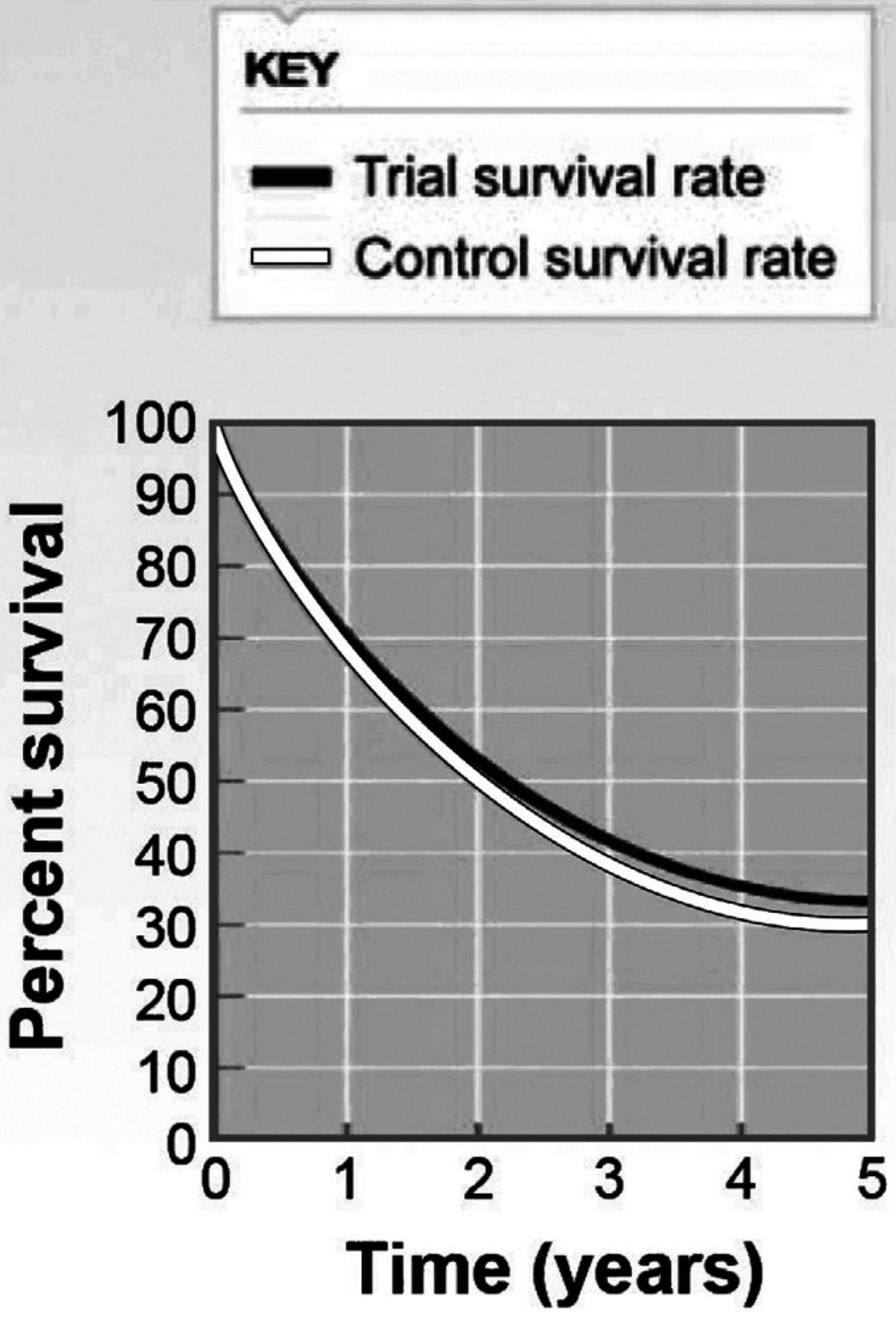
22

X

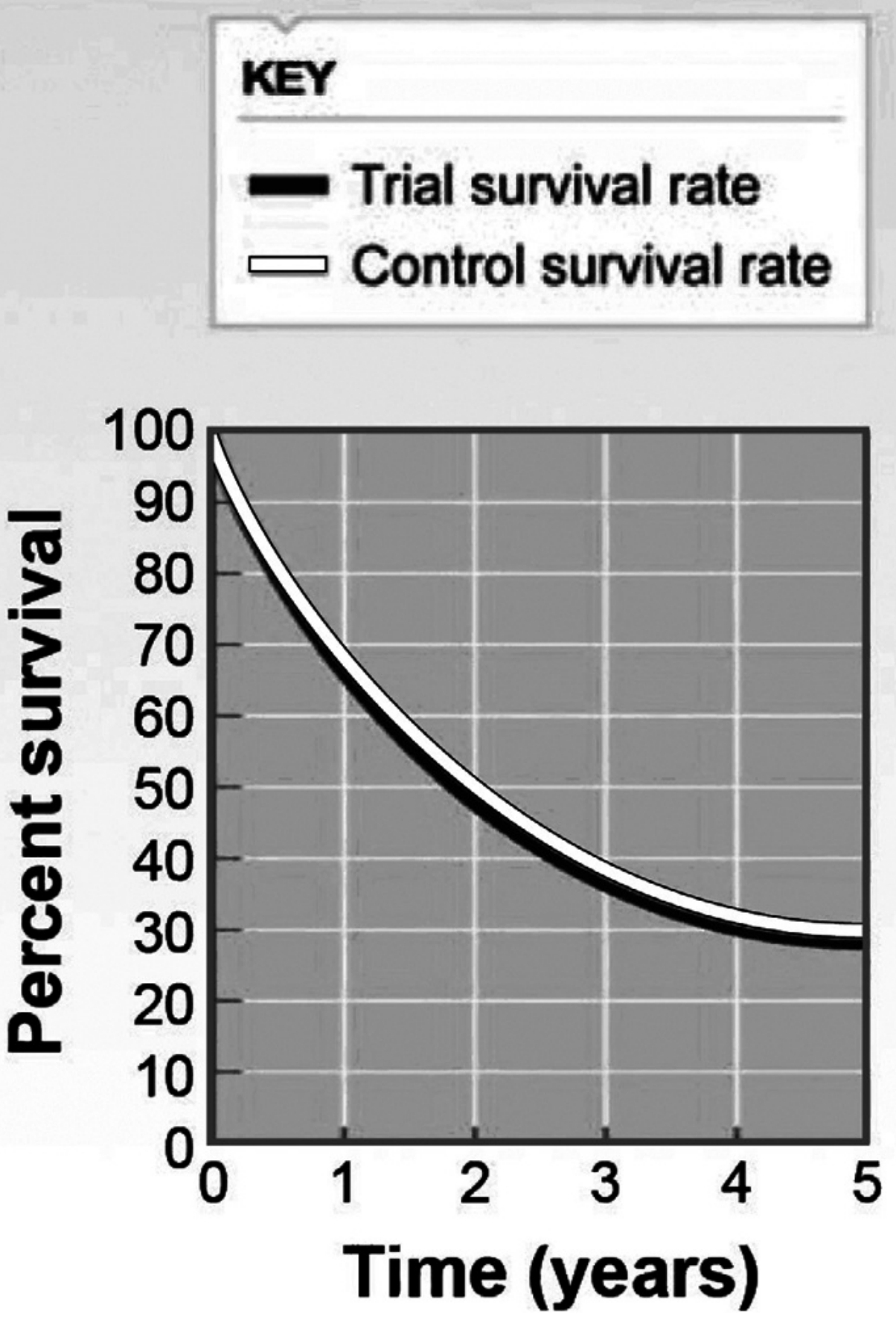
Y

Master 4.12

Results


KEY
Trial survival rate
Control survival rate
Percent survival
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)

Results


KEY
Trial survival rate
Control survival rate
Percent survival
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)

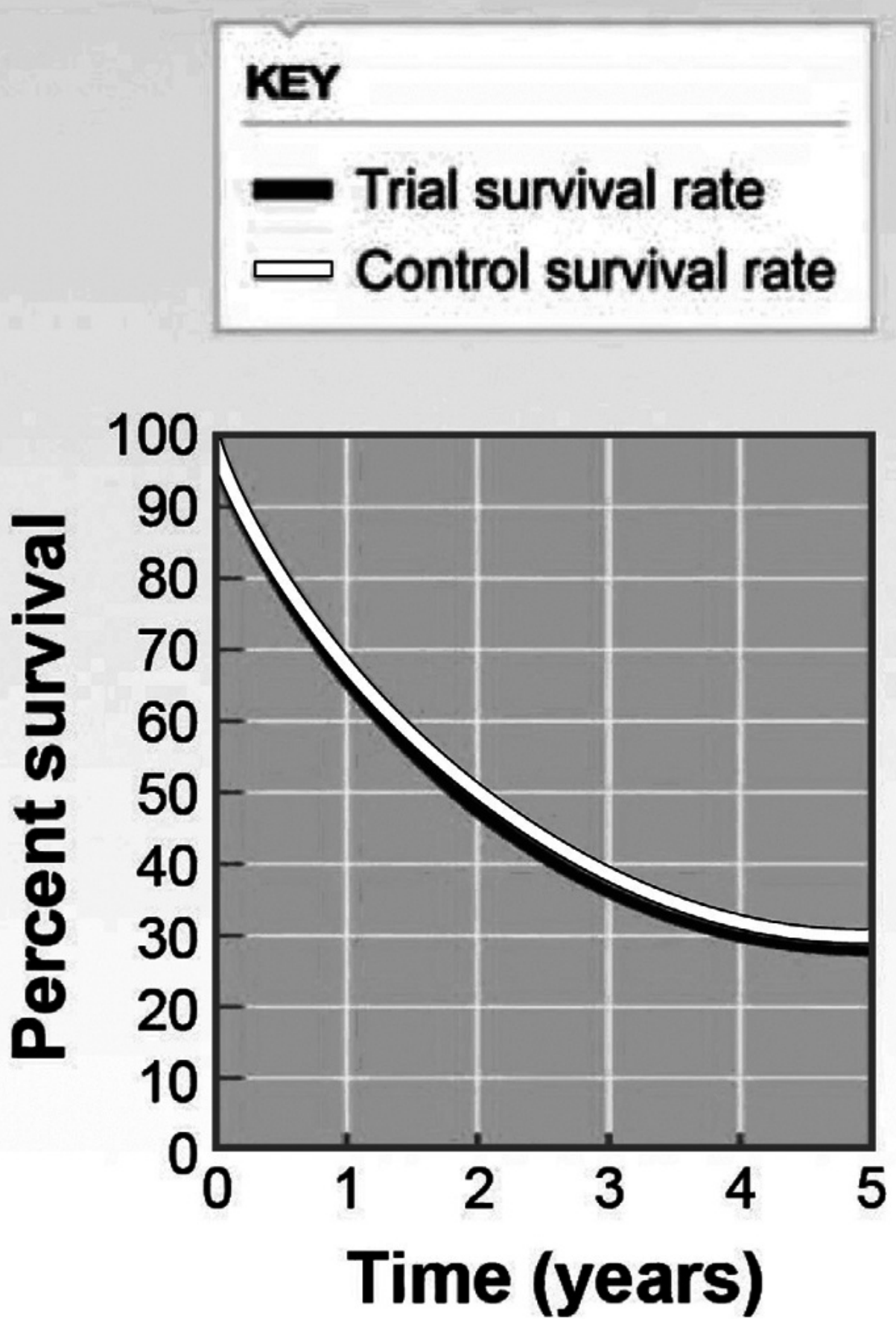
Changing the Dose of Drug A

Figure 1. Drug A, increased dose.

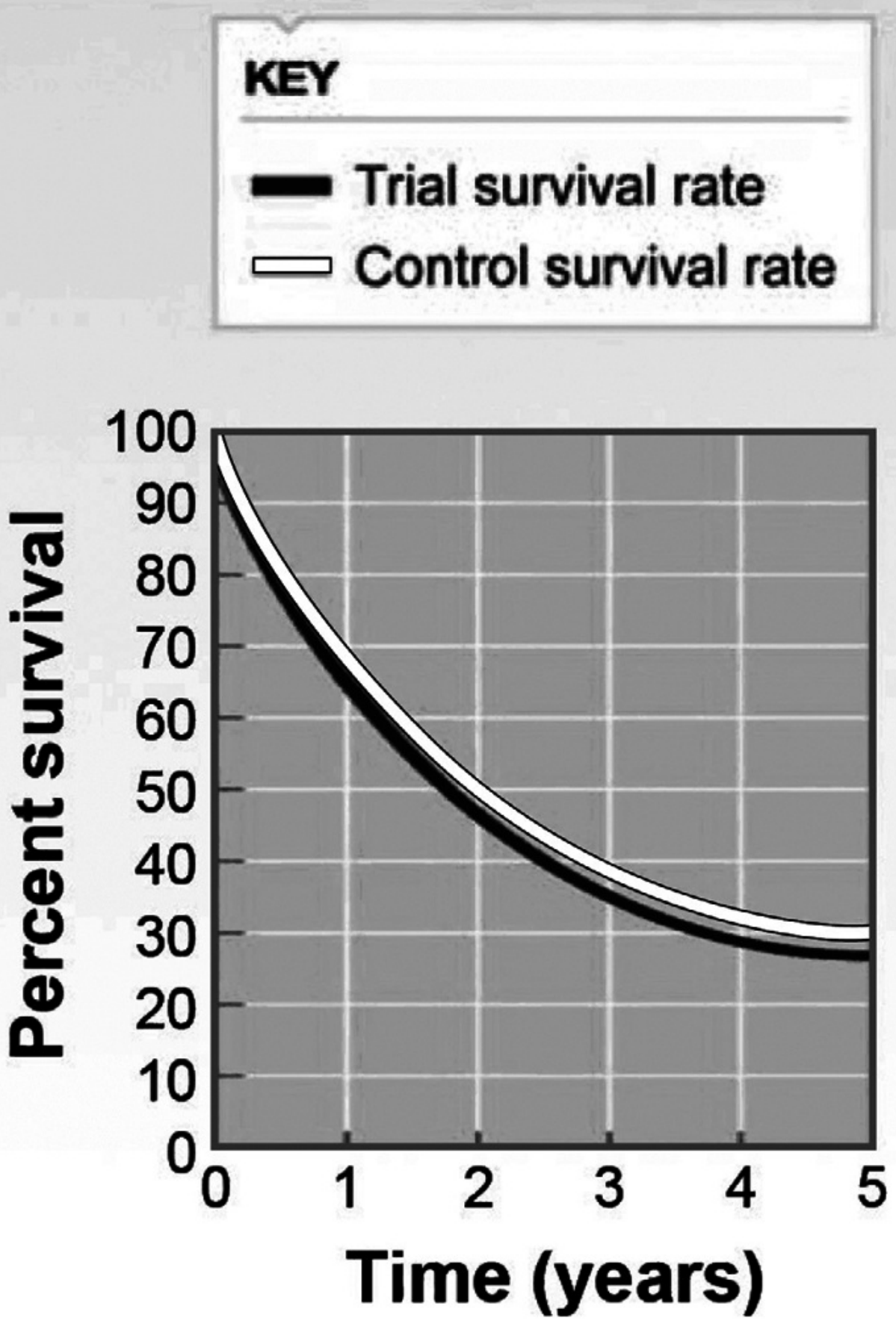
Figure 2. Drug A, decreased dose.

Master 4.13

Results


KEY
Trial survival rate
Control survival rate
Percent survival
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)

Results


KEY
Trial survival rate
Control survival rate
Percent survival
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)

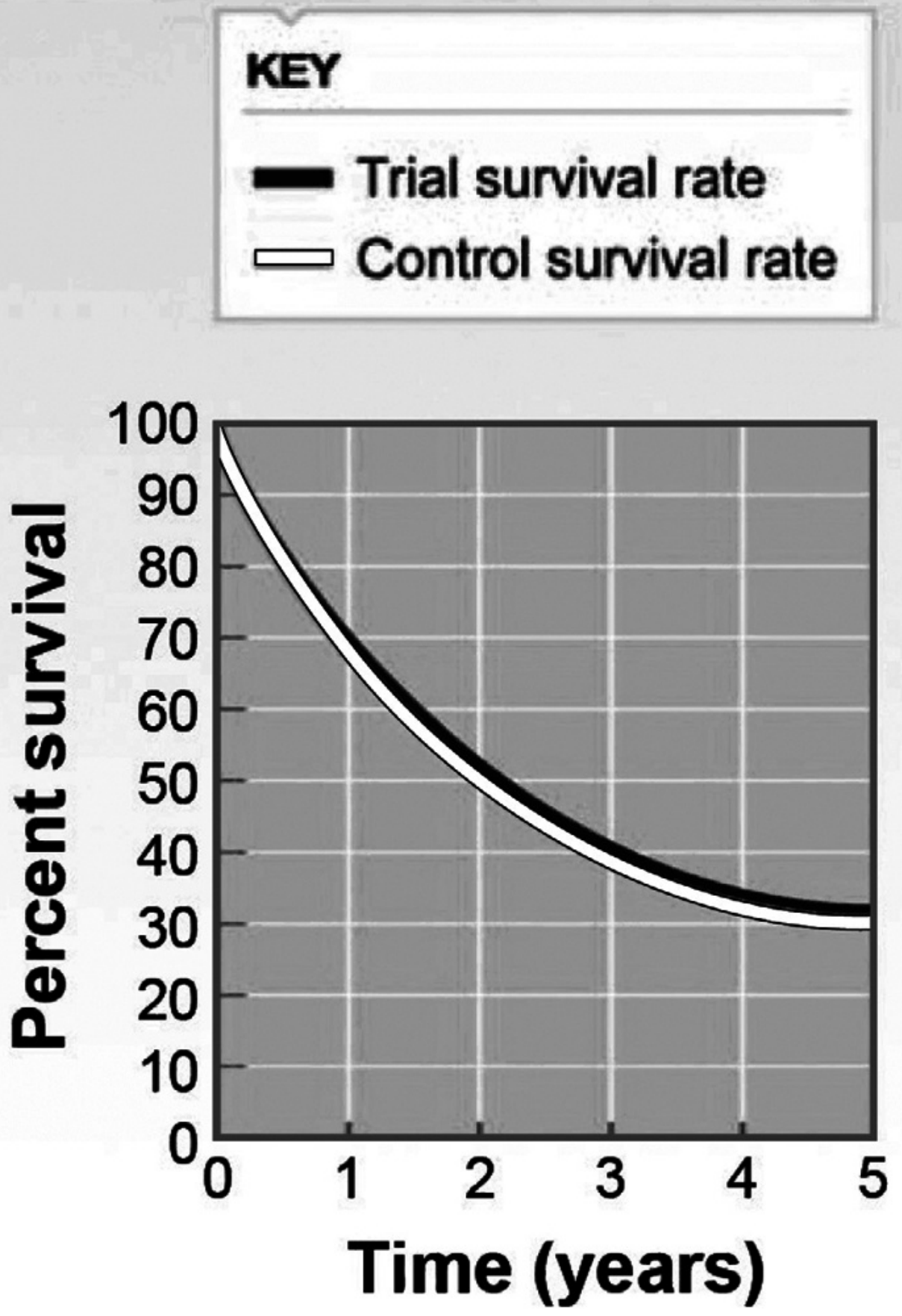
Changing the Dose of Drug B

Figure 1. Drug B, increased dose.

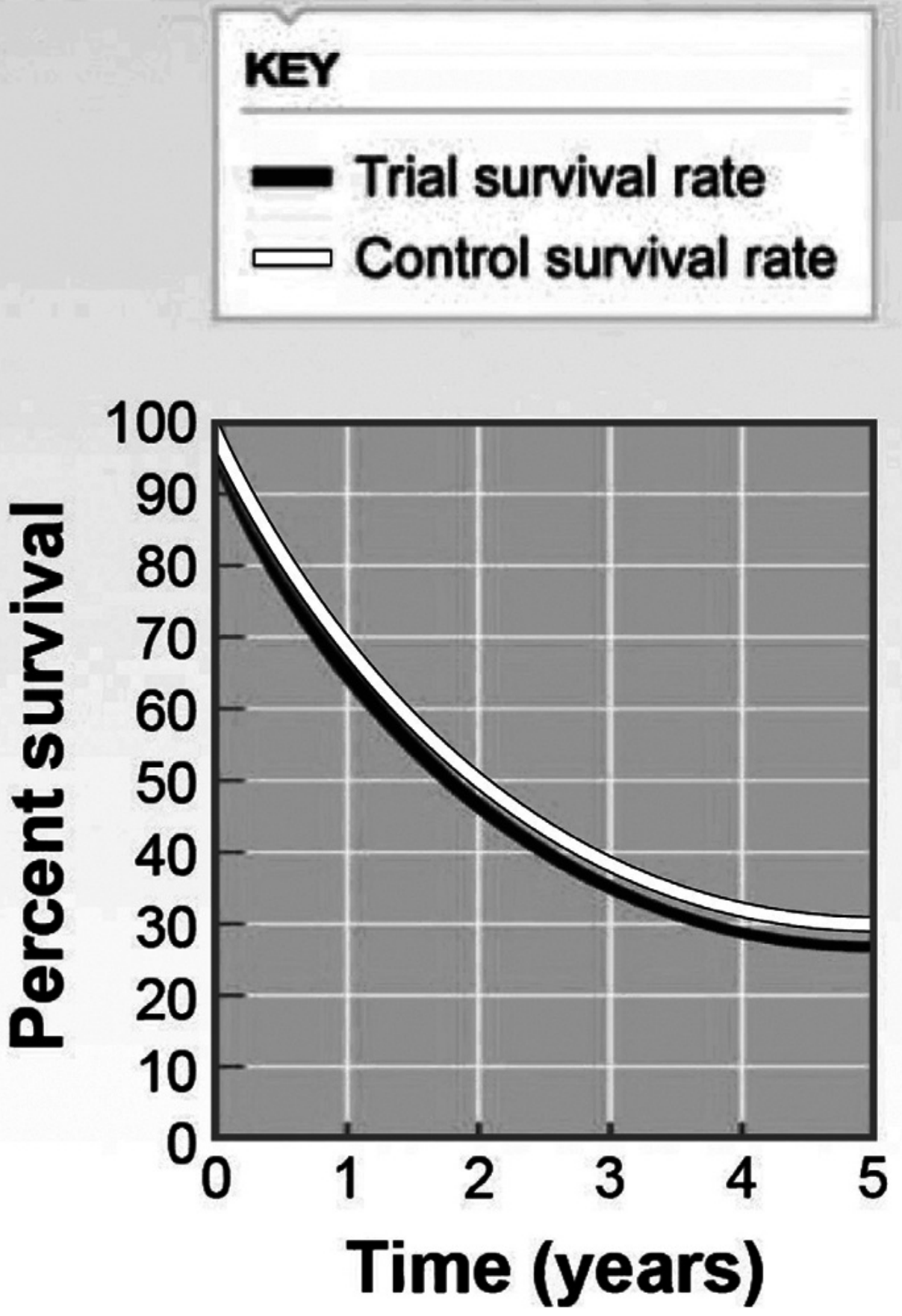
Figure 2. Drug B, decreased dose.

Master 4.14

Results


KEY
Trial survival rate
Control survival rate
Percent survival
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)

Results


KEY
Trial survival rate
Control survival rate
Percent survival
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)

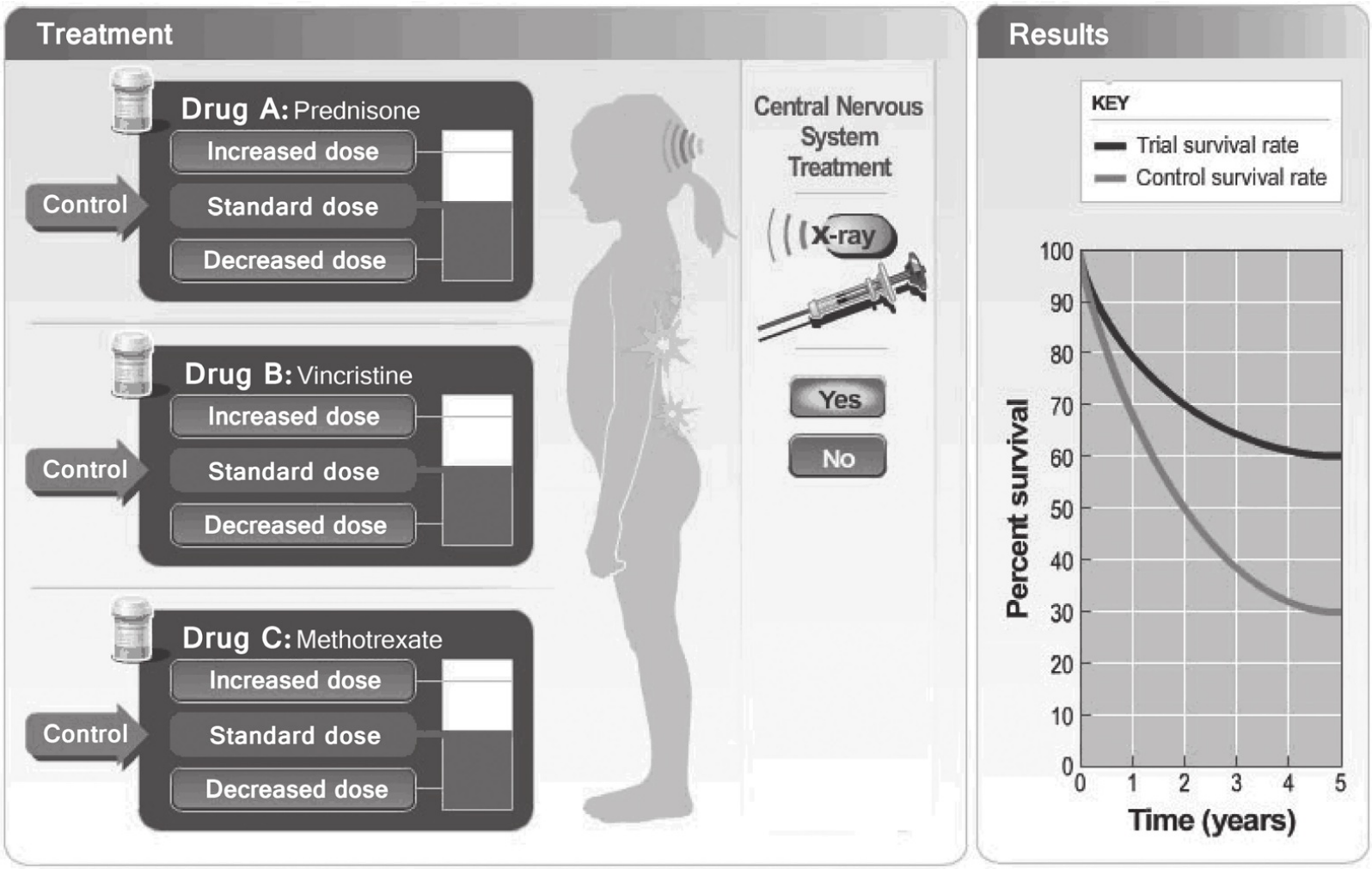
Changing the Dose of Drug C

Figure 1. Drug C, increased dose.

Figure 2. Drug C, decreased dose.

Master 4.15

Permission granted for classroom use.



Central Nervous System Treatment

Figure 1. Designing a clinical trial. Left: Design of an experiment using standard doses of drugs A, B, and C with and without the central nervous system treatment. Right: Results of the experiment, where Trial is with the CNS treatment and Control is without it.

Master 4.16

Permission granted for classroom use.

Interview with Hailey

INTERVIEWER: What was it like to go to a new high school after undergoing treatment for leukemia?

HAILEY: Being a freshman is hard already, but for me, it was even harder. After a year away, I didn't really fit in. I wasn't the same as the other kids. They were thinking about cars, cell phones, and dating. Some days, all I could think about was dragging myself to the next class without throwing up. It was strange; here I was, surrounded by 2,000 other people, and I felt more alone than I'd ever been in my entire life.

INTERVIEWER: So what happened?

HAILEY: Slowly, things started to change. I met new friends who made me laugh, and I reconnected with old friends I'd known since elementary school. My teachers helped me, too. Mr. Brinthom got me involved in theater, which made every day a new adventure. Dr.

Bradley and my other teachers helped me discover a love of learning, especially science.

INTERVIEWER: Now that you're through with your treatment, what has cancer taught you?

HAILEY: Having cancer changed me. I had a new purpose. I wanted to help other teens who were going through the same thing.

INTERVIEWER: How did you go about helping teens with cancer?

HAILEY: I started delivering gift bags to a local hospital. Some people noticed and started sending me money to keep going—and I got noticed by the Leukemia and Lymphoma Society. I was even awarded the Spirit of Tom Landry Award last year by Mrs. Landry herself.

INTERVIEWER: What are your plans for the future?

HAILEY: I want to devote my life to fighting cancer as a pediatric oncologist. In the meantime, I'm helping out at events like a fashion show just for cancer patients.

INTERVIEWER: What can the rest of us do?

HAILEY: You don't have to find the cure for cancer to help someone in your own community. Sometimes, you just have to be there. Just get involved and do something—big or small.

Master 4.17

Guidelines for the Poster

The information on your poster should be written in clear sentences

in paragraph form.

Part I: Information about the Disease

• What is the name of the disease?

• Is it a common or a rare disease?

• What are the disease symptoms?

• Who gets the disease?

• What causes the disease (and how do we know)?

• How is the disease treated?

• How might having the disease affect a person's

• ability to participate in normal activities?

• relationships with family, friends, classmates, and strangers?

Part 2: Summary of a Clinical Trial or Research Study

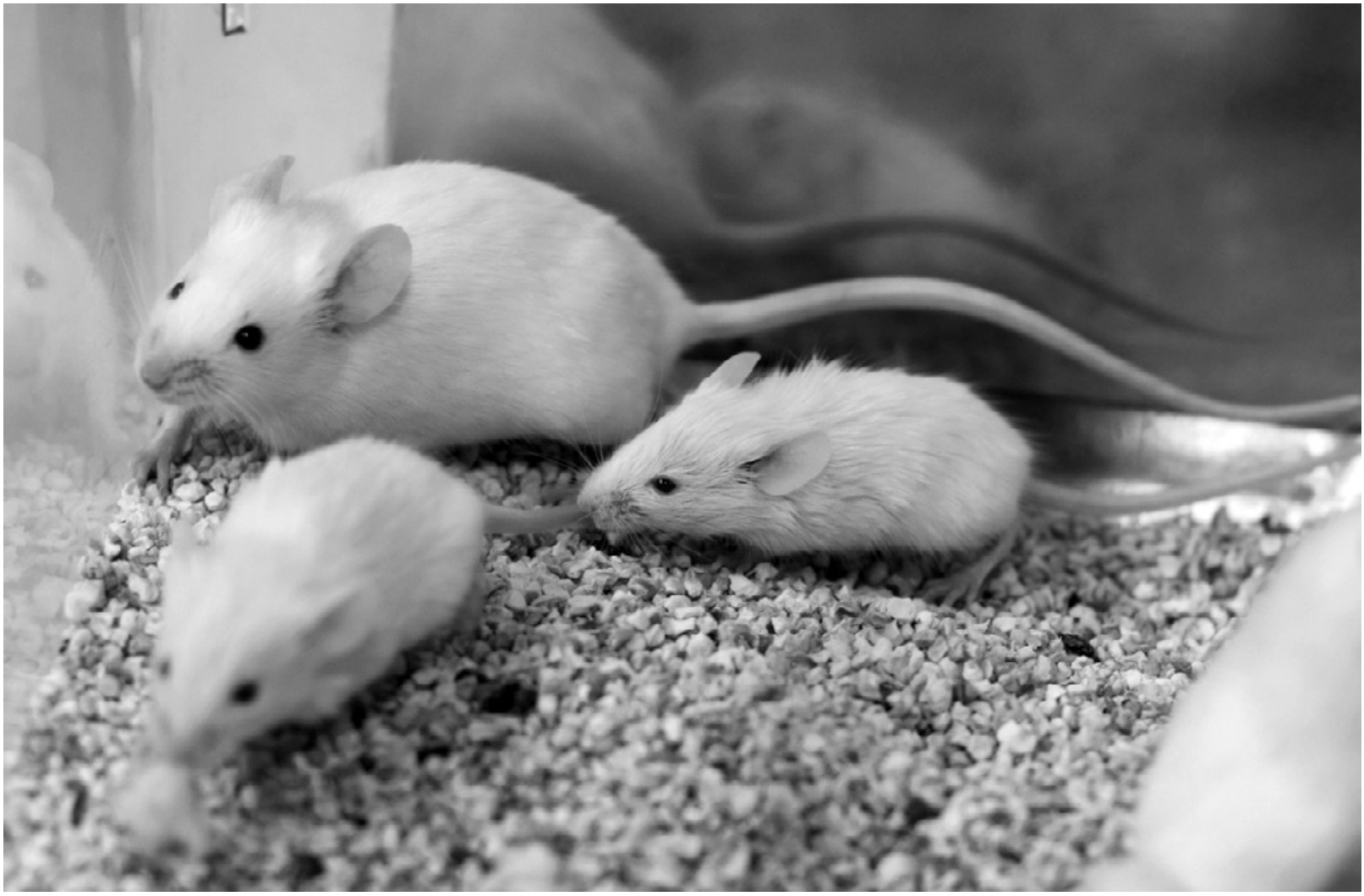
• What is the purpose of the clinical trial or research study?

• Describe how the clinical trial or research study was carried out.

• What were the results of the clinical trial or research study?

• What can you conclude from the evidence presented?

Master 5.1



Research Study on Marfan Syndrome

Figure 1. Mice with the Marfan mutation. **(© Brandon Laufenberg | iStockphoto.com) 1. Background**

A drug called losartan is used to treat people with high blood pressure.

Many problems caused by Marfan syndrome, such as an enlarged aorta (blood vessel), are due to a substance that works as a signal between cells. If too many signals are sent, the aorta grows too big. When it becomes too big, it is weaker and tears more easily. Researchers wonder if a drug called losartan can block this substance and keep the aorta at the normal size. They are testing this drug first in mice with Marfan syndrome and then, they hope, in humans.

2. Study design

The study used three groups of mice:

Group 1: Healthy mice (without Marfan syndrome). They received no treatment.

Group 2: Mice with Marfan syndrome. They received no treatment.

Group 3: Mice with Marfan syndrome. They received the drug losartan.

After receiving the drug (or not) for six months, the amount of growth in the heart's aorta was measured.

Table 1. Marfan Study Results

Treatment group	Average amount of growth in aorta
Healthy mice (no drug)	0.20 millimeters
Marfan mice (no drug)	0.66 millimeters
Marfan mice (treated with drug)	0.18 millimeters

Clinical Trial on Childhood Leukemia

Figure 1. Combination drug therapy. **(EyeWire)**

Figure 2. Brain irradiation. **(© Colleen Butler |**

iStockphoto.com)

1. Background

Since the 1960s, children with leukemia have had their heads X-rayed to prevent brain cancer. This treatment has worked well. Survival rates of children with leukemia have improved. Unfortunately, this treatment can also harm the ability of the brain to carry out its job.

Using more than one drug at the same time also has helped improve survival rates of children with leukemia. Researchers wondered whether the careful use of multiple drugs could keep survival rates high without using X-rays.

2. Study design

Children were assigned to one of two groups:

Group 1: Received combination drug therapy alone.

Group 2: Received combination drug therapy along with brain irradiation.

Table 1. Childhood Leukemia Study Results

Treatment group

5-year survival rate

Drug combination therapy without brain irradiation

94 percent

Drug combination therapy with brain irradiation

93 percent

Master 5.3

Permission granted for classroom use.

Evaluation Rubric for Poster

Category

Excellent

Good, but could be Needs a lot of

(5 points)

better

improvement

(3 points)

(1 point)

Information Each item on Part 1

Some items on Part 1 Most items on Part 1

about the

of Master 5.1 is

of Master 5.1 are not of Master 5.1 are not

disease is

addressed.

addressed.

addressed.

complete.

Information Each item on Part 2

Some items on Part 2 Most items on Part 2

about the

of Master 5.1 is

of Master 5.1 are not of Master 5.1 are not

clinical trial addressed.

addressed.

addressed.

or research

study is

complete.

Information Statements about

Some supporting

Most supporting facts

on the

the disease are

facts are missing or

are missing or they are

poster is

supported by all

some supporting

inaccurate.

accurate.

relevant facts.

facts are not

Facts are accurate.

accurate. Some

Unrelated facts are

supporting facts are

not included.

not relevant.

Information There are no errors in There are a few

There are many errors in

on the

spelling or grammar.

errors in spelling or

spelling and grammar.

poster

grammar.

is clear

and well

written.

Poster

Poster design is

Poster design is

Poster looks like it was

design is

especially attractive,

reasonably attractive, made without much

creative

and the information

and most of the

thought to an attractive

and well

is clearly presented.

information is clearly and clear presentation.

executed.

presented.

Master 5.4

Permission granted for classroom use.

Poster Score Sheet

Name:

Use the evaluation rubric to score the poster. Enter your score for each category on this score sheet. Include a specific reason (or reasons) for each score given.

Code number for the poster being evaluated

Category

Score

Reason for score

(For example, if you fi nd an inaccurate statement

on the poster, list it here and include a correction.)

Information about the

disease is complete.

Information about the

clinical trial or research

study is complete.

Information on the

poster is accurate.

Information on the

poster is clear and well

written.

Poster design is creative

and well executed.

Total score

Master 5.5

What Do You Think Now?

Name:

1. What is a disease?

2. How do doctors tell if someone has a disease?

3. What do you think causes disease?

4. What does it mean to call a disease “rare”?

Master 5.6

PEOPLE REALITY

Productions

Another Letter from the Producer

Dear Principal:

I am pleased to learn that you are still interested in helping us develop our reality television show. We have been busy interviewing young people who have a rare disease, and we have selected a boy named Kevin to be the focus of the show.

Kevin has been diagnosed with a rare disease called Marfan syndrome. He is outgoing and loves sports, though recently he has had to give up playing because of his Marfan syndrome. Kevin has developed an interest in videography and has a real talent for it. He is eager to join the class and even wants to film parts of the show himself!

I will be bringing Kevin to the school sometime next month to meet you, your staff, and, most importantly, the students who will become his classmates. Of course, if you have any questions, please contact me.

Once again, thank you for your help with this project.

Sincerely,

Vincent Shifflett

Senior Producer

People Reality Productions

Master 5.7

Document Outline

COPYRIGHT INFORMATION