How does where you live and work affect your risk for mesothelioma?

Grade Band: *High School* • Discipline: *ESS* • Time: *Two 50-minute class periods*

**Lesson Level Performance Expectation**

- Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources; consider limitations of the data and use evidence to explain how the extraction of a specific natural resource (asbestos) has affected disparities in the risk of mesothelioma in the United States.

**What Students Will Figure Out**

- Asbestos exposure is linked to mesothelioma.
- There are disparities in the risk of mesothelioma in the United States.
- There are genetic risk factors for mesothelioma. People who inherit a mutated BAP1 gene have a higher risk for developing mesothelioma, especially if exposed to asbestos.
- When analyzing data, it is important to consider the limitations of data and what additional information you would like to know.
Lesson Snapshot

High School students, as scientists, use science ideas about natural resources to investigate the following driving question: How does where you live and work affect your risk for mesothelioma? Students analyze data about disparities in mesothelioma cases in Ambler, Pennsylvania, and two surrounding cities and decide to investigate the difference in case numbers. Students obtain and evaluate information and data about mesothelioma, asbestos, asbestos mining, and genetic risk factors for mesothelioma. Students also evaluate information and analyze data about a second city, Libby, Montana. Students figure out that the disparate mesothelioma case numbers in the two cities are caused by multiple factors including asbestos exposure and genetics. Students write an explanation of the disparities in mesothelioma case numbers.

Phenomenon:

Mesothelioma 1992 - 2008
Ambler - Observed vs. Expected

<table>
<thead>
<tr>
<th>Observed</th>
<th>Expected</th>
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<tbody>
<tr>
<td>28</td>
<td>9.09</td>
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</table>

Number of cases

Source: Pennsylvania Department of Health: Cancer Evaluation Ambler Area, Montgomery County

Science and Engineering Practices

Analyzing and Interpreting Data
• Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Obtaining, Evaluating, and Communicating Information
• Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Disciplinary Core Ideas

ESS3.A: Natural Resources
• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

Crosscutting Concepts

Cause and Effect
• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

This lesson could be one in a series of lessons building toward the following Performance Expectation(s):

HS-ESS3-3. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]
## Materials

### Student Materials

**Per Student**
- Mesothelioma Student Guide
- Science History.org: Ambler, PA: Living in the Town Asbestos Built
- The Guardian: Welcome to Libby, Montana, the town that was poisoned
- New York Times: Ex-Worker Wins $36.5 Million From Company That Hid Asbestos Damage

**Per Small Group (2 to 4 students)**
- Computer or tablet to access materials

### Teacher Materials

- NIH: Finding Reliable Health Information Online
- CDC: Mesothelioma Map Average Number of Cases of Mesothelioma Over a Five-Year Period
- CDC: Mesothelioma Map Age Adjusted Incidence Rate of Mesothelioma per 100,000 population Over a Five-Year Period
- USGS: Asbestos Mine Map
- International Journal of Environmental Research and Public Health: Asbestos in High-Risk Communities

### Optional Teacher Resources

#### Teaching Research Skills
- MLA: Vertical Checklist
- ERIC: Just Say No! Teaching Students to Resist Scientific Misinformation
- Oregon State University: Fact Checking in an Era of Fake News
- Utah Education Network: Evaluate Websites Using the CRAP Checklist

#### Asbestos and Mesothelioma
- EPA: Asbestos
- Montana State University: Libby Asbestos Health Status Project
- Journal of Occupational and Environmental Medicine: Follow-Up of the Libby, Montana Screening Cohort
- Asbestos.com: How Did Asbestos Contaminate Libby?
- Missouri Department of Health and Senior Services: Age adjusted rate definitions
- New York State Department of Health: Age-Adjusted Rates - Statistics Teaching Tools
- Statista: Major countries in worldwide asbestos mine production in 2021
- Asbestos.com: Mesothelioma & Asbestos Worldwide
- Translational Lung Cancer Research: Expanded Genetic Research about Malignant Mesothelioma
- Understanding Health Research: Confounders
- NIH: Confidence intervals
- NIH National Cancer Institute: Asbestos Exposure and Cancer Risk

#### Instructional Strategies
- AdLit: Inferential Reading Strategy
- NSTA: Focusing the Lens of the Crosscutting Concepts on Secondary Science Learning

#### Health Disparities in the United States
- American Journal of Public Health: Moving Forward: Breaking the Cycle of Mistrust between American Indians and Researchers
- The Journal of Health Care for the Poor and Underserved: More than Tuskegee: Understanding Mistrust about Research Participation

#### Supporting Student Writing of Explanation
- NSTA: Argumentation and Explanation: Tools for Using them Together While Keeping Them Separate by Bryan Flaig
- STEM Teaching Tools: Practice Brief 1: Distinguish between the explanation and argumentation practices.
Lesson Preparation

Required Prior Knowledge: This lesson assumes students already had an opportunity to figure out the following science ideas.

**MS ESS3.C: Human Impact on Earth’s Systems**
- Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

**LS1.A: Structure and Function**
- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules.
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)

**LS1. B: Growth and Development of Organisms**
- In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

**LS3.A: Inheritance of Traits**
- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species’ characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

**LS3.B: Variation of Traits**
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

**Constructing Explanations and Designing Solutions**
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources.
Experience the Phenomenon

What Students Are Doing

In this section, students are introduced to the phenomenon. Students ask questions about mesothelioma and consider how where you live and work could affect your likelihood of developing mesothelioma. Students decide to investigate more about mesothelioma and its causes.

Teacher Guidance

1. **Ask students if they have ever heard of mesothelioma.**
   Ask students if they have ever heard of Mesothelioma. Ask students who have heard of it to share what they know, or what they think they know about it. Listen carefully to what students share about mesothelioma; their ideas will provide insight into what they already know about the disease. In the next steps, be sure to highlight the places in the student guide or readings that correct or confirm any information students share during this step.

2. **Ask students to analyze the phenomenon on page 1 of the Student Guide.**
   Phenomenon: Between 1992 and 2008, the rate of mesothelioma in Ambler was 3.1 times higher than expected, based on statewide rates for this cancer type. Men had 2.7 times the expected rate, and women had 4.5 times the expected rate. These differences were all statistically significant. The mesothelioma rates for Blue Bell and Fort Washington were not elevated.
   
   If students ask for more information about the location of these towns, let them know that they are located in Montgomery County, Pennsylvania, and are considered suburbs of Philadelphia.
   
   After students work independently for a few minutes, ask them to discuss their patterns and observations with a partner. Next, facilitate a whole class discussion about what they explored with their partners.

<table>
<thead>
<tr>
<th>Suggested prompts</th>
<th>Sample student responses</th>
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</thead>
<tbody>
<tr>
<td>What do you notice about the map?</td>
<td>There are three locations identified on the map: Blue Bell, Fort Washington, and Ambler. The zip codes are with the cities. There is a red dot identifying “Borit Asbestos Superfund Site” in Ambler.</td>
</tr>
<tr>
<td>What do you notice about the graph?</td>
<td>There were 28 cases of mesothelioma in Ambler between 1992 and 2008; they expected to have only 9.09 cases. 3x the expected rate.</td>
</tr>
</tbody>
</table>

3. **Record the class questions about the phenomenon:**
   Ask students to share their questions about the map and graph. Their questions should be displayed publicly so students can reference their questions throughout this lesson. The questions could be written on sticky notes, a whiteboard, or a digital platform that is visible to all.
How does where you live and work affect your risk for mesothelioma?

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<tbody>
<tr>
<td>What questions do you have about the map and graph?</td>
<td>How did they collect this data about mesothelioma cancer rates?</td>
</tr>
<tr>
<td></td>
<td>Why were the rates higher in Ambler and not Blue Bell or Fort Washington?</td>
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<tr>
<td></td>
<td>Why are the cancer rates so different for men and women?</td>
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<tr>
<td></td>
<td>What does it mean when something is “statistically significant”?</td>
</tr>
<tr>
<td></td>
<td>What is asbestos?</td>
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<tr>
<td>What are the limitations of this information? What</td>
<td>How did they collect the data? Are there people who had mesothelioma and</td>
</tr>
<tr>
<td>additional data would you like to consider?</td>
<td>didn’t know it who were left out?</td>
</tr>
<tr>
<td></td>
<td>Are there other places in the U.S. with high rates of mesothelioma?</td>
</tr>
<tr>
<td>What other questions do you have about the phenomenon?</td>
<td>If people get this type of cancer, will they die? Is there a treatment?</td>
</tr>
<tr>
<td></td>
<td>What is mesothelioma?</td>
</tr>
<tr>
<td></td>
<td>What can be done to protect yourself from getting it?</td>
</tr>
</tbody>
</table>

4. **Point out that several students had questions about mesothelioma and what causes it.**

Identify that many students had questions about mesothelioma, and those questions are a great place to start figuring out what happened in Ambler, Pennsylvania. Suggest that students do some research to find out what exactly mesothelioma is.

As students obtain and evaluate information, they may authentically wonder about the driving question of this lesson “How does where you live and work affect your risk for mesothelioma?” When the question comes up, make sure to highlight it as the question they will continue to investigate.

Note: Much of the information available online about mesothelioma is published by law firms or other groups with a financial or legal reason for publishing information. It is important to approach researching this disease with strong digital literacy skills.

5. **Introduce the “vertical” and “lateral” methods to evaluate sources.**

Project a search engine and ask the class to observe as you search using the phrase “What is mesothelioma?” The websites returned will include a mix of sources that might all appear factual.

Review the NIH page [Finding Reliable Health Information Online](https://www.nitpical.org) with students. Highlight the importance of checking the site “vertically” for the components mentioned on the NIH site including the websites’ purpose, publisher, authors, reviewers, and date published. See the Additional Guidance section for more teacher support guiding “vertical” and “lateral” research.

Divide students into small groups to have them research the questions “What is mesothelioma?, What causes mesothelioma?, and What is asbestos?” Tell groups that they must provide evidence from sources and keep track of additional questions that surface during their research on the Student Guide. In a later step, the class discussion will require information from the [NIH National Cancer Institute](https://www.nitpical.org) website. Be sure at least one group uses the NIH National Cancer Institute website during their research.

Have students return to a whole class discussion and share their findings. At this time, they will compare their results “laterally” to see if multiple sources and sites provide the same information. Below are sample student responses. If students have found variation in their searches, discuss the differences and unpack what sources yielded reliable or biased results.
How does where you live and work affect your risk for mesothelioma?

### Research Questions

<table>
<thead>
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<tr>
<td>What is mesothelioma? (me-zoe-thee-lee-O-muh)</td>
<td>Malignant mesothelioma is a type of cancer that occurs in the thin layer of tissue that covers the majority of your internal organs (mesothelium). Mesothelioma is an aggressive and deadly form of cancer. Mesothelioma treatments are available, but for many people with mesothelioma, a cure isn’t possible.</td>
</tr>
<tr>
<td>What causes mesothelioma?</td>
<td>Primary risk factor for mesothelioma is asbestos exposure, though most people with asbestos exposure never develop mesothelioma. There are other ARDs (asbestos-related diseases). The major ARDs are asbestosis, lung cancer, and malignant mesothelioma. There is something called a “latency period” which means that from the first time someone is exposed to asbestos it can be between 10 and 50 years before the ARD is noticed.</td>
</tr>
<tr>
<td>What is asbestos?</td>
<td>Asbestos is a term used for a group of six naturally occurring, fibrous, silicate minerals. They are also known as actinolite, amosite, anthophyllite, chrysotile, crocidolite, and tremolite. These minerals are used in brake linings, heat resistant materials, roofing composites, and in heat and electrical insulations.</td>
</tr>
<tr>
<td>Did anyone’s group get other answers to these questions?</td>
<td>Responses will vary. Some groups may say “Yes, but we realized that the site we were searching was published by a law firm representing people suing asbestos companies,” or “No, it seems like all our answers are about the same, which tells us that we can trust the information we’ve found so far”.</td>
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### Suggested prompts

<table>
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<tr>
<td>Now that we know mesothelioma is a cancer caused by asbestos, what other questions do we need to answer next to find out what is happening in Ambler?</td>
<td>Is there asbestos in or near Ambler? Are there other places like Ambler with high mesothelioma rates? What other factors may be involved in determining whether someone gets mesothelioma?</td>
</tr>
<tr>
<td>With the information you know now, where would you expect to find high rates of mesothelioma?</td>
<td>Areas with asbestos deposits. Places with manufacturing or use of asbestos fibers.</td>
</tr>
<tr>
<td>How could we investigate that prediction?</td>
<td>Look at data or maps of mesothelioma and U.S. asbestos mines.</td>
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</table>

6. **Navigate to the next question students will investigate.**

Revisit the initial questions students generated in step 2. Indicate which questions they have already answered and notice which questions remain. The goal of this step is to get students to decide to look at maps of mesothelioma occurrences and asbestos mine locations.
Additional Guidance

Asbestos abatement and mitigation

This lesson does not directly address abatement or mitigation strategies for asbestos or asbestos-containing products. Discussion of the risk/benefits of abatement and how to contain or mitigate risks during renovations, may be one of the ways that students have heard of asbestos or mesothelioma before. Visit the EPA site Asbestos to learn more about asbestos to find state-specific information about asbestos.

Each state has different asbestos programs and environmental protection organizations. In some cases, state contacts specialize in federal requirements such as the Asbestos Hazard Emergency Response Act (AHERA) and the asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP). Twelve states have an AHERA waiver to implement and oversee their own asbestos-in-schools regulations. Those states include Connecticut, Colorado, Illinois, Kentucky, Louisiana, Massachusetts, Maine, New Hampshire, Oklahoma, Rhode Island, Texas, and Utah.

Lateral and Vertical Research

In the past, direct instruction about fact-checking looked at a website or source “vertically.” Many students have followed checklists verifying if a source is credible by assessing the source’s authority, purpose, accuracy, currency, and relevance. However, in the digital age, verifying a source through vertical reading can be quite difficult, as some internet sites are deliberately designed to be misleading. Additionally, now that most students can access information via the internet, they should not be restricted to vertical reading. Instead, current recommendations suggest teaching to read “laterally,” that is, by examining other sources and triangulating findings. Stanford History Education Group’s (SHEG) approach to this involves validating a target source using six steps: investigate the source’s author, perform keyword searches, verify information and quotations, research citations, look up organizations cited, and analyze sponsorship or ads (Walsh-Moorman et al., 2020). To support digital literacy in your students, consider further reading or lessons in evaluating sources.

MLA Vertical Checklist: a sample checklist to assess the credibility of a source.

Just Say No! Teaching Students to Resist Scientific Misinformation by Andrew Zucker, Pendred Noyce, and Andrew McCullough

Fact Checking in an Era of Fake News Lesson Plan, Oregon State University: Students will learn how to identify valid and reputable sources of news by reviewing a variety of information sources, including paper-based and web-based, using the CRAAP Test (originally developed by CSU Chico), and lateral reading. This activity provides an opportunity for students to learn more about how news is generated and how to think critically about the information available to them, either throughout their day or while researching a specific topic.

Utah Education Network: Evaluate Websites Using the CRAP Checklist. Students will compare two websites and evaluate them using the “CRAP checklist.” They will look at factors like currency, reliability, accuracy, and purpose.
Investigate the Phenomenon

What Students Are Doing

In this section, students investigate more of their questions about mesothelioma rates in Ambler, Pennsylvania, and uncover that another location, Libby, Montana, also has elevated asbestos-related cancers. Students analyze multiple data sources including a study that showed that exposure to asbestos does not always lead to mesothelioma. Students investigate questions related to the study and determine that there are genetic risk factors for mesothelioma. People who inherit a mutated BAP1 gene have a higher risk for developing mesothelioma.

Teacher Guidance

7. Provide asbestos and mesothelioma data for students to analyze.

Remind the class that some students asked if there are other places in the United States with high rates of mesothelioma where there were asbestos mines. Direct them to the links in the Student Guide that lead to two digital maps showing mesothelioma incidence and the USGS mine information. Tell students to read the information and analyze the data presented in these maps.

Note: Be sure that students hit the “Play” button on the upper left corner of the maps to see the data displayed over time. The Crosscutting Concept lens of Cause and Effect may be helpful in supporting student sensemaking when looking at the maps. See additional resources for more ideas about using the CCC in instruction.

Below are screenshots of the three maps.

Sources: CDC Mesothelioma Map Average annual number of cases of mesothelioma over a 5-year period
CDC Mesothelioma Map Age-adjusted incidence rate of mesothelioma per 100,000 population over a 5-year period
USGS Asbestos Map
How does where you live and work affect your risk for mesothelioma?

8. **Facilitate a Building Ideas discussion.**

After students work independently for a few minutes, ask them to discuss their observations and any patterns they have noticed with a partner. Then bring the class together and facilitate a Building Ideas Discussion.

<table>
<thead>
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<tbody>
<tr>
<td>What do you notice about the two different CDC maps? How do the maps vary over time?</td>
<td>One map is the “average number of cases of mesothelioma over a 5-year period” and the other map is “age-adjusted incidence rate of mesothelioma per 100,000 population over a 5-year period”. When we hit “play” the locations where more cases were reported varied over time. More states reported more mesothelioma over time, but some states did not report data during all the date ranges. We are surprised that the maps measuring mesothelioma don’t have the same distribution of states with darker colors. We expected to see the same states with higher concentrations of cases in both maps.</td>
</tr>
<tr>
<td>Why does the Average number of cases over a five-year period map look different from the Age-adjusted incidence rate per 100,000 population over a five-year period map? Are there limitations of this information? What additional data would you like to consider?</td>
<td>The average number of cases over five years does not take into consideration how populated a state is and the distribution in age of the state’s population. For example, the average annual number of cases of mesothelioma over a five-year period shows that California, New York, Florida, and Texas (all states with many people who live in them) have higher rates. The rates may be higher because there is a higher concentration of mesothelioma. Those rates may also be higher because more people in the age range that get diagnosed with mesothelioma live there. We can’t be sure without digging into that data more. The age-adjusted incidence rate per 100,000 population is a way to make a fairer comparison between states with different age distributions and population numbers. Age-adjusting the rates ensures that differences between states are not due to the differences in the age distribution of the populations being compared. We saw in the map that Montana and Maine, states with low to mid population density had high incidence of mesothelioma in 2012 to 2019. Are there any places like Amber in Maine or Montana?</td>
</tr>
<tr>
<td>What populations/datasets are not available and how might their absence influence the causality analysis?</td>
<td>We noticed that some states didn’t display results. The legend indicated they were “suppressed” during different year ranges. According to the NIH site, using U.S. Cancer Statistics methods, data have been suppressed to ensure confidentiality and stability of rate estimates. Data are suppressed if fewer than 16 cases were reported in a specific population category or where there are 100 or fewer persons in the denominator. Blanks or missing data within the maps, tables, and charts may be due to one of the following reasons: (1) data were not collected, (2) data were collected but were not provided to CDC, or (3) data were incomplete or did not meet data quality standards.</td>
</tr>
<tr>
<td>What types of measurable data are not available for analysis but could assist in interpreting this phenomenon? What other types of data (e.g. qualitative) might be important to consider/understand in interpreting these outcomes?</td>
<td>This map looks at the entire U.S. We want to dig more deeply into Ambler, Pennsylvania, to see if what happened there happened anywhere else. The data in the maps shows mesothelioma, but not all asbestos-related diseases.</td>
</tr>
<tr>
<td>What do you notice about the USGS Asbestos mines, prospects, and occurrences in the U.S.? What about in Ambler, PA (Montgomery County)?</td>
<td>The pattern of mines occurs on the East and West coasts. The green squares are prospect or occurrence, the red indicates a mine past or present producer and the white is labeled as “other.” When we zoom in to Ambler, PA, we don’t see any mines in the city itself. We see a few occurrences and mines to the southwest of Ambler. Is that where the asbestos came from? We need to know more about the maps and mines. How were people in Ambler exposed to asbestos if there wasn’t a mine there? Do people who live in Ambler work in the mines? How does where you live and work affect your risk for mesothelioma?</td>
</tr>
</tbody>
</table>
9. **Share information about a city similar to Ambler called Libby, Montana.**

Point out that from the Building Ideas discussion, students had questions about finding out if there were other places like Ambler in the United States. Tell students that you did some searching based on their questions and found some information about asbestos and mesothelioma in another city.

Project the map of Libby, Montana, and read the following information:

- From 1979 to 1998, asbestos mortality in Libby, Montana, was 40 to 80 times higher than expected compared to Montana and the United States. (Source: Libby Asbestos Health Status Project)
- A study reported a 15-fold increased risk of mesothelioma among W.R. Grace workers (asbestos mining in Libby) compared to residents who didn’t work around the mine between 2000 and 2016. (Source: How did asbestos contaminate Libby?)
- The study’s data also show elevated mortality for some asbestos-related causes in groups of people who did not work at the mine. (Source: Follow-Up of the Libby, Montana, Screening Cohort)

This step provides an excellent opportunity to discuss confounders, confidence intervals, and how to be cautious with interpreting data but also to identify that the burden of proof isn’t always the role of science. See Additional Guidance for more information.

10. **Lead a discussion to generate student ideas about what information to obtain next to figure out the phenomenon.**

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<tr>
<td>Libby, MT, has higher rates of death due to ARD, and Ambler, PA, has higher rates of mesothelioma. Are those two statistics comparable?</td>
<td>Kind of? They are both ARD, but since the measurements are different, we can’t directly compare them to each other. We know that both towns have been impacted by asbestos, but the types of data aren’t the same. Looking at ARD deaths and rates of cancer are different.</td>
</tr>
<tr>
<td>The quantitative data is measuring different statistics. What limitations are there to this data?</td>
<td>Comparing quantitative data can be difficult when the units being compared aren’t the same and scientists haven’t collected the same kind of data about different populations. We need to be careful about the kinds of claims we make when the data isn’t the same.</td>
</tr>
<tr>
<td>What other data or information would help you understand if where you live and work affects your risk for mesothelioma?</td>
<td>We need to learn more about life in Libby and Ambler. How are Libby and Ambler the same? How are they different?</td>
</tr>
</tbody>
</table>
11. Direct students to analyze articles about life in Libby, Montana, and Ambler, Pennsylvania.
Remind students that they wanted more qualitative information about life in the two towns. Share that you found articles written about life and asbestos in both Libby and Ambler.

When reading articles, students must analyze the text carefully to distinguish between opinion and fact. When students infer, they figure things out that are not directly stated in the text. They can connect what they read to what they already know to go beyond the text. When discussing portions of a reading passage this can sound like “The article states _____, and I know ______, so I think ______.” Inference is important because everything someone needs to know is not always directly stated in the text. For additional support in teaching inferencing, see the Additional Guidance Section.

Divide the class into smaller groups to read the in-depth information about Libby and Ambler. Prompt students to discuss at least two of the three articles in light of the data presented in the previous step.

**Articles**
- ScienceHistory.org: [Ambler, PA: Living in the Town Asbestos Built](#)
- The Guardian: [Welcome to Libby, Montana, the town that was poisoned](#)
- New York Times: [Ex-Worker Wins $36.5 Million From Company That Hid Asbestos Damage](#)

12. Ask students to share their findings from the articles.
Regroup the class and hold a Building Understanding discussion. Have students share the opinions and facts they discovered in the articles. Encourage them to build on one another’s ideas and challenge each other to clarify or fully explain their inferences. Below is a sample of what the discussion might include:

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<tbody>
<tr>
<td>What did you find out about life in Ambler and Libby?</td>
<td>Responses will vary but should include reference to textual evidence describing the small size of the towns and their reliance on the asbestos industry and the student guide responses.</td>
</tr>
<tr>
<td>How do these articles help us answer our phenomenon question “How does where you live and work affect your risk for developing mesothelioma?”</td>
<td>Responses will vary but should reference specific quotations from the text explaining that many people living in Libby and Ambler were employed by the asbestos industry. Many of the people working were exposed to asbestos, but did not develop mesothelioma. The Ambler article mentioned something about genetic predispositions being a risk factor too. We need to find out more about that.</td>
</tr>
</tbody>
</table>

13. Navigate to discussing the genetic risk factors for mesothelioma
Ask students to consider this quotation from the Ambler article.

_Fox Chase Cancer Center’s Joseph Testa, the researcher working on genetic predispositions, says that as a general rule there is no safe level of exposure. “Any exposure to asbestos is potentially carcinogenic,” he says, while also emphasizing that mesothelioma is a relatively rare disease. Of the many asbestos workers who inhaled the mineral every day for years, only a minority went on to develop mesothelioma.”_

Ask students to share the questions that come up when they read this quotation.
Sample Student Questions

- If asbestos is carcinogenic how can only a small number who inhaled asbestos get mesothelioma?
- So is he saying that two people can inhale the same amount of asbestos, but it has different effects in their bodies? How?
- It says he was working on genetics, could this have something to do with why different people experience different effects from mesothelioma?

Tell students that you have some information about genetics and mesothelioma that could help answer their questions. Direct students to review the Genetic Risk Factors of Mesothelioma from Asbestos.com and the Cancer.gov Fact Sheet. Give students time to evaluate the information individually and communicate their ideas with a partner. Then, facilitate a whole class discussion of the resources.

<table>
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<tr>
<td><strong>Point out that students had asked previously “Why do only some people develop mesothelioma after the same amount of exposure to asbestos?”</strong></td>
<td>The primary risk factor for mesothelioma cancer is exposure to asbestos fibers. Research shows people who inherit a mutated BAP1 gene are more vulnerable to developing mesothelioma, especially if exposed to asbestos. Genetic biomarkers can be used for early detection of mesothelioma. (Source: Asbestos.com)</td>
</tr>
</tbody>
</table>
| **What factors affect the risk of developing an asbestos-related disease?** | Several factors can help to determine how asbestos exposure affects an individual, including:

  • Dose (how much asbestos an individual was exposed to)
  • Duration (how long an individual was exposed)
  • Size, shape, and chemical makeup of the asbestos fibers
  • Source of the exposure
  • Individual risk factors, such as smoking and pre-existing lung disease
  • Genetic factors, such as having a germline mutation in BAP1

Although all forms of asbestos are considered hazardous, different types of asbestos fibers may be associated with different health risks. For example, the results of several studies suggest that amphibole forms of asbestos may be more harmful than chrysotile, particularly for mesothelioma risk, because they tend to stay in the lungs for a longer period of time (1, 2). (Source: Cancer.gov Fact Sheet) |

We know that some behaviors or environmental exposures can lead to different kinds of cancer. We know that environmental UV exposure increases risk for skin cancer and behaviors, like smoking, can increase their risk for lung cancer. These environmental and behavioral risk factors are really individual. Can someone’s behavior increase their risk for ARD? | Many studies have shown that the combination of smoking and asbestos exposure is particularly hazardous. Smokers who are also exposed to asbestos have a risk of developing lung cancer that is greater than the individual risks from asbestos and smoking added together (3, 6). There is evidence that quitting smoking will reduce the risk of lung cancer among asbestos-exposed workers (4). Smoking combined with asbestos exposure does not appear to increase the risk of mesothelioma (10). However, people who were exposed to asbestos on the job at any time during their life or who suspect they may have been exposed should not smoke. (Source: Cancer.gov Fact Sheet) |
Additional Guidance

Additional Information about Libby Montana

- Source: Montana State University: Libby Asbestos Health Status Project
- Source: Journal of Occupational and Environmental Medicine: Follow-Up of the Libby, Montana Screening Cohort
- Source: Asbestos.com: How Did Asbestos Contaminate Libby?

Tools for understanding the data represented in the CDC maps of mesothelioma

**Age-adjusted rate definitions** Age adjusting rates is a way to make fairer comparisons between groups with different age distributions. For example, a county having a higher percentage of elderly people may have a higher rate of death or hospitalization than a county with a younger population, merely because the elderly are more likely to die or be hospitalized. (The same distortion can happen when comparing races, genders, or time periods.) Age adjustment can make the different groups more comparable.

A “standard” population distribution is used to adjust death and hospitalization rates. The age-adjusted rates are rates that would have existed if the population under study had the same age distribution as the “standard” population. Therefore, they are summary measures adjusted for differences in age distributions.

**Age-Adjusted Rates—Statistics Teaching Tools** How is age-adjustment done?

Age confounding occurs when the two populations being compared have different age distributions, and the risk of the disease or outcome varies across the age groups. The process of age-adjustment by the direct method changes the amount that each age group contributes to the overall rate in each community, so that the overall rates are based on the same age structure. Rates that are based on the same age distribution can be compared to each other without the presence of confounding by age. Adjustment is accomplished by first multiplying the age-specific rates of disease by age-specific weights. The weights used in the age-adjustment of cancer data are the proportion of the 1970 U.S. population within each age group. The weighted rates are then summed across the age groups to give the age-adjusted rate. Age-adjustment is demonstrated here using the cancer mortality rates for all sites of cancer among men in New York State in 1994.

Nonfiction Text Inferencing

**Inferential Reading Strategy**

Teaching students to “read inferentially” helps them learn how to read more strategically. This technique is derived from the teaching model that learners develop knowledge via the process of interpreting new information in light of past experiences and rethinking past knowledge based on new information.

Optional extension: Look at a global scale for mesothelioma rates and asbestos mining

- Major countries in worldwide asbestos mine production in 2021
- Mesothelioma & Asbestos Worldwide

Expanded Genetic Research about Malignant Mesothelioma

Malignant mesothelioma (MM) is a relatively rare cancer frequently linked to prior exposure to asbestos. Approximately 3,000 new cases of MM are diagnosed annually in the United States. As a cancer of the mesothelial cell lining that surrounds various organs, the majority of MM (~80%) occurs in the pleural cavity surrounding the lungs, whereas most of the remaining (peritoneal) tumors arise in the abdominal cavity. Prognosis is generally very poor with a median survival of ~9–12 months for pleural cases (1,2). Similar to other cancers, MM is a disease that can result from the interactions between environmental carcinogenic factors (e.g., asbestos) and genetic predisposing factors, only one of which has been identified to date. At the somatic genetic level, losses of chromosome regions 3p21.1, 9p21.1, and 22q12.2 are frequently observed in MM. The critical driver genes located at 9p21.1 and 22q12.2 were first reported more than two decades ago as being the tumor suppressor loci CDKN2A and NF2, respectively (3,4). Only relatively recently was the BAP1 gene determined to be
How does where you live and work affect your risk for mesothelioma?

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the driver gene at 3p21.1 that is frequently somatically inactivated (5), and germline mutations of BAP1 predisposing to MM were reported independently at about the same time (6). Numerous studies have confirmed that BAP1 is a major MM susceptibility gene, and that most MMs (>80%) harbor somatic alterations of the CDKN2A locus, which encodes the tumor suppressor proteins p16INK4A and p14ARF (regulators of the critical Rb and p53 pathways, respectively), 60% harbor somatic mutations and exonic deletions of the BAP1 gene, and 30–50% show inactivation of NF2.


Sex Disparity in Ambler cancer rates

In Ambler, Pennsylvania, the relative risk was higher in women than in men (4.5 in women, 2.7 in men). Two possible explanations for this somewhat surprising difference are outlined below.

1) Men may have worn protective equipment (e.g., face masks) while at work, but brought home asbestos fibers on their clothing, which traditionally would be washed by women in the household, since it is likely that exposures occurred in the 1930s to 1950s, and it is likely that warnings about not bringing home asbestos-contaminated clothing didn’t occur until the 1960s and later. 2) Since the relative risk ratio uses the number of cases of mesothelioma in men and women in the “non-exposed” regions of the state as the denominator, it is likely that the denominator in men in the comparison areas was substantially higher than for women because of other occupational exposures to men, but not women. Since mesothelioma is very rare in the absence of substantial exposures, the actual number of cases for women in the control area is likely to be very small. The difference between “relative risk” and “absolute risk” is an interesting discussion to have with students if they probe this idea. This also brings up the opportunity to discuss the important differences between workplace, lifestyle (e.g., smoking, alcohol, diet), and other environmental exposures (e.g., living in a community with contaminated air or water that exposes everyone, not just workers).

Using the Crosscutting Concepts

Focusing the Lens of the Crosscutting Concepts on Secondary Science Learning

By Brett Criswell, Christopher Roemmele, and Missy Holzer

Confounders + Confidence Intervals

If you have time, step 7 is a great place to discuss confounders, confidence intervals, and how to be cautious with interpreting data but also to identify that the burden of proof doesn’t always have to be on the science. There are many factors with mesothelioma, ARD, and where someone lives and works. If your class is ready to discuss additional considerations when looking at data, this is an excellent opportunity to discuss these ideas.

• Confounders
  • Confounders: Understanding Health Research. A confounder (or ‘confounding factor’) is something, other than the thing being studied, that could be causing the results seen in a study. It can be very difficult to account for every possible confounder when doing research with people, but researchers must try to account for anything that could influence their results when planning their research and analyzing their data. confounders have the potential to change the results of research because they can influence the outcomes that the researchers are measuring.

• Assessing bias: the importance of considering confounding. It is common to come across a study that reports that treatment A “provided significantly better pain relief” than treatment B. When a difference in an outcome (e.g., pain) between exposures (e.g., treatment groups) is observed, one needs to consider whether the effect is truly because of exposure or if alternate explanations are possible.

• Confidence Intervals
  • Confidence intervals are frequently reported in scientific literature and indicate how close research results are to reality, or how reliable they are, based on statistical theory.
How does where you live and work affect your risk for mesothelioma?  High School • Discipline: ESS

**Explain the Phenomenon**

**What Students are Doing**
Students use data they have analyzed about mesothelioma and asbestos, information about the genetic risk factors for mesothelioma, and qualitative information obtained and evaluated to write a final explanation of the phenomenon.

**Teacher Guidance**

14. Facilitate a Consensus Discussion.

Ask students to pause and consider all that they have figured out about mesothelioma and the two cities of Ambler and Libby. Prompt students to revisit their initial questions and see which ones they have yet to answer.

<table>
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<td>Could someone restate what we were trying to figure out?</td>
<td>We were trying to figure out if where you live and work affects your risk of developing mesothelioma. We heard about a town called Ambler, PA, where the rates for mesothelioma were really high and we want to explain why.</td>
</tr>
<tr>
<td>What are some things we think we can say about the phenomenon?</td>
<td>We know that asbestos exposure is linked to developing mesothelioma, but a small percentage of people exposed to asbestos develop mesothelioma. The people living in Ambler and the other city we looked at, Libby, MT, were exposed to asbestos because many people in the town either worked or lived with someone who worked in the asbestos industry. We also know that there is a genetic component related to the fact that the BAP1 gene is a tumor suppressor gene driving malignant mesothelioma. People who smoke are more likely to develop lung cancer, and people who smoke and were exposed to asbestos are even more likely to develop lung cancer. However, people who were exposed to asbestos and smoke are not more likely to develop mesothelioma.</td>
</tr>
<tr>
<td>What is our evidence for all those ideas?</td>
<td>We researched all those topics on websites and read articles. We looked “vertically” and “laterally” at the sources to make sure they were credible. We also made inferences about what was fact and opinion in the articles we read.</td>
</tr>
</tbody>
</table>
15. **Provide an overview of how students will write their final explanation of the phenomenon.**

Revisit the components of a complete explanation with the class. To support student success, generate an explanation checklist as a class to ensure that students have the key components of their explanation in their writing. Below is a sample conversation about collaboratively generating the explanation checklist. A blank checklist and sample completed checklist are in the Student Guide.

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<td>What components, relationships, and mechanisms should you include in your explanation to answer the driving question “How does where you live and work affect your risk for developing mesothelioma?”</td>
<td>Um, we don’t know. What are those things again?</td>
</tr>
<tr>
<td>Components are the factors you should show and explain in your explanation. What are some components you think should be included in a complete explanation?</td>
<td>OH! Right…um, we should include: mesothelioma, asbestos, and risk factors for sure.</td>
</tr>
<tr>
<td>What about relationships? Relationships are the factors you should connect. What relationships should you highlight in your explanation?</td>
<td>We should include a few relationships. Definitely the relationship between asbestos exposure and ARD and the relationship between asbestos exposure and mesothelioma. Also the other risk factors including smoking and the genetic tumor suppressor BAP1. Do you think we should mention the things we thought were going to have a relationship but weren’t what we expected?</td>
</tr>
<tr>
<td>What do you mean?</td>
<td>Like, we thought that the two CDC maps would show the same patterns of where people got mesothelioma, but the maps looked totally different because of the way the data was displayed. And we thought that everyone exposed to asbestos would develop mesothelioma, but that isn’t what happens.</td>
</tr>
<tr>
<td>For your explanation, focus on sharing facts and ideas that answer the driving question. The components + the relationships are the mechanisms. The mechanisms deeply explain the answer to our driving question.</td>
<td>OK, so we think the mechanism we should focus on is the mutated BAP1 gene and the other risk factors for developing mesothelioma, including living or working with asbestos fibers.</td>
</tr>
<tr>
<td>YES! You can include things that you thought would be relationships, but make sure to indicate that your thinking has changed. Go ahead and get started. If you need a table to organize your ideas you can use the list we just generated.</td>
<td></td>
</tr>
</tbody>
</table>

**Sample Student Response Should Include**

- Cited evidence gathered. The sources we should use include:
  - Both CDC maps
  - USGS mine location map
  - Articles about life in Ambler and Libby
  - Research about risk factors for ARD and mesothelioma
- Reasoning
  - Connecting the evidence to what we know about location and risk for mesothelioma.
  - Connecting the evidence to what we know about work and risk for mesothelioma.
- A claim to answer the driving question “How does where you live and work affect your risk for mesothelioma?”
How does where you live and work affect your risk for mesothelioma?

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16. **Direct students to write their explanations.**

Allow ample time for students to reflect on and synthesize their ideas into an explanation.

If students struggle, consider providing sentence frames to support writing or have them work in small groups to draft explanations together. Note that most graphic organizers and writing formats use CER (Claim, Evidence, Reasoning) and guide students to identify their claim first. Some students struggle to make a claim before engaging with their evidence. Below, the sentence frames ask students to start with their evidence and reasoning. Once they have provided evidence and reasoning, they can identify the claim with their evidence and reasoning support. See Additional Guidance for additional resources to support students engaging in argumentation and explanation.

**Evidence:**
- We found that ________ is caused by _______ because ________.
- Our evidence comes from...[name of the type of data and the part of the lesson it came from].
- Reasoning:
  - We think this evidence supports the idea that ________ [state a brief causal chain of events—this chain has to be consistent with known science facts].

**Claim:**
- Where you live and work [does/do not] affect your risk for mesothelioma because...

17. **Facilitate presentations, peer-to-peer review, and revisions.**

Facilitate public presentations of student explanations. This can take the format of a gallery walk or partner sharing. Ask students to read their explanation aloud to their audience. After reading, have peers provide feedback or suggestions for ways to clarify the explanation. This allows students to express their ideas and thinking while their peers evaluate the evidence and reasoning of the explanation. After switching roles and listening to their peers’ explanations, have students reflect if they would like to add, edit, or revise their explanation.

18. **Provide time for students to revise their explanations.**

Direct students to incorporate edits or additions based on peer feedback. Provide time for students to revise and submit their final explanations answering “How does where you live and work affect your risk for mesothelioma?”

**Additional Guidance**

Students will likely notice that some health data are widely available online, this is the case for mesothelioma. This is not the case for all diseases or all populations. An optional extension discussion would be for students to consider which populations and what diseases are widely researched and published. This discussion should lead to a conversation about health disparities in the United States. There are working groups at NIH focused on these inequalities.

**The State of Health Disparities in the United States.** As part of its statement of task, the committee was asked to review the state of health disparities in the United States and to explore the underlying conditions and root causes contributing to health inequities and the interdependent nature of the factors that create them (drawing from existing literature and syntheses on health disparities and health inequities). In this chapter the committee reviews the state of health disparities in the United States by race and ethnicity, gender, sexual orientation and gender identity, and disability status, highlighting populations that are disproportionately impacted by inequity. In addition, this chapter summarizes data related to military veterans as well as rural versus urban-area differences. The committee drew on existing literature, comprehensive reviews (AHRO, 2016; NCHS, 2016), and recent studies. In Chapters 2 and 3, the report features examples of communities that are taking action to address the root causes of health inequity. These brief examples are meant to be illustrative of the work being undertaken by communities throughout the country. In Chapter 5, the report takes a more in-depth look into nine examples of community-driven solutions to promote health equity.
As mentioned in health disparity research, health outcomes for all racial and ethnic groups are not published with the same level of depth, nor do certain groups report or trust researchers to share health information. Consider how groups of people have been treated by the medical research establishment and how that may impact under-reported or under-researched health issues.

- Moving Forward: Breaking the Cycle of Mistrust Between American Indians and Researchers
- More than Tuskegee: Understanding Mistrust about Research Participation

**Supporting Student Writing of Explanations:**

- NSTA Argumentation and Explanation: Tools for Using them Together While Keeping Them Separate
- STEM Teaching Tools Practice Brief 1: Is it important to distinguish between the explanation and argumentation practices in the classroom?