Activity Time: 75 Minutes (the end of one class, plus one class period).

Lesson Plan Summary:
In this lesson, students will increase their understanding of Bovine Spongiform Encephalopathy (BSE). Students will read specific case studies and participate in an interactive simulation related to protein structure. A variety of extension activities are provided to help students learn about the disease pathology, the causative agents, animal susceptibility, and the regulatory and surveillance measures that protect animals and humans from BSE.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding:

- **Disease Forensics and Risk Management:** Disease forensics involves developing an understanding of the contributing factors of BSE and the feed practices that minimize the risk of BSE outbreaks.

Essential Questions:

- What is mad cow disease, or BSE? What is the disease history and what is the disease prevalence today?
- What has been the health and economic impact of BSE worldwide?
- What is the perceived and real risk of transmission of BSE to humans?
- What is a prion? How does it cause tissue damage and death in animals?
- How do state and federal agencies reduce the risk of BSE through regulations and surveillance efforts?

Learning Objectives:

*Students will know...*

- Transmissible spongiform encephalopathies (TSEs), also known as prion diseases, in both animals and humans are characterized by tiny holes in brain tissue that give the brain a spongy appearance and result in physical and behavioral changes. TSEs are always fatal.
- BSE, the prion disease of cattle, is incurable and 100% fatal.
- Since the 1980’s, veterinarians, neurobiologists, and scientists have increased our understanding of these diseases—but we still have many unanswered questions.
- Countries with cases of BSE experienced catastrophic and lasting impacts to the vitality of the beef trade resulting in major revisions in feed and animal husbandry, surveillance, and oversight worldwide.
- BSE is a feedborne disease and a zoonotic disease.
- The WSDA plays an important role in regulating animal feed to prevent the spread of BSE.
Students will be able to...

- Explain how prions contribute over time to the formation of deadly spongiform pathology.
- Summarize how prions enter the food chain.
- Appreciate the hazards inherent in consuming Specified Risk Materials.
- Discuss BSE surveillance programs.
- Summarize the role of the Washington State Department of Agriculture (WSDA) and the U.S. Food and Drug Administration (FDA) in regulating animal and human food sources, from both domestic and imported sources.

Vocabulary:

- Animal byproducts
- Bovine Spongiform Encephalopathy (BSE)
- Chronic Wasting Disease
- Creutzfeldt-Jakob Disease (CJD)
- Fatal Familial Insomnia (FFI)
- Genetic susceptibility
- Immune system
- Kuru
- Mad Cow Disease
- Offal
- Post-mortem
- Prion (both normal-PrPC prions and abnormal-PrPSc prions)
- “Prohibited Materials”
- Protein
- Protein folding/misfolding
- Rendered meat products
- Ruminant animals
- Scrapie
- Specified Risk Materials (SRMs)
- Sporadic Creutzfeldt-Jakob Disease (sCJD)
- Transmissible Spongiform Encephalopathies (TSEs)
- Variant Creutzfeldt-Jakob Disease (vCJD)
- Zoonotic disease
Standards Alignment:

This lesson addresses the following Washington State Essential Academic Learning Requirements (EALRs) and/or Grade Level Expectations (GLEs) for grades 9–12:

- **Science EALR 1 (9-12 SYSC):** In complex systems, entirely new and unpredictable properties may emerge. Consequently, modeling a complex system in sufficient detail to make reliable predictions may not be possible.

- **Science EALR 1 (9-12 APPE):** Analyze a societal issue that may be addressed through science and/or technology. Compare alternative solutions by considering trade-offs and unintended consequences (e.g., removing dams to increase salmon spawning).

This lesson addresses the following Washington State Career and Technical Education (CTE) model frameworks for Agriculture, Food, and Natural Resources (AFNR):

- **AS.03.01:** Prescribe and implement a prevention and treatment program for animal diseases, parasites, and other disorders.

- **AS.03.02:** Provide for the biosecurity of agricultural animals and production facilities.

- **AS.04.02.01.b:** Discuss how feed additives are administered and the precautions that should be taken. Level II.

- **FPP: 01.01.02.a:** Identify and explain environmental and safety concerns about the food supply. Level I.

- **FPP.02.03.04.a:** Explain the importance of record keeping in a food product and processing system.

Common Student Preconceptions:

- Animal diseases are limited in their scope and impact.

- There are many cases of “mad cow disease” (more accurately called BSE) annually and that’s why we need to spend money on preventing this disease.

- Mad cows get the disease from feed that contains common pathogens, such as bacteria, viruses, or parasites.

- Like animal diseases caused by a bacteria, virus, or parasite, we already know how to prevent and/or treat mad cow disease.

- Mad cows can transmit the disease to healthy cows just by getting too close to them.

- This disease has been contained to a limited number of cases worldwide (and particularly in the U.S.) so surveillance efforts are not needed.
TEACHER PREPARATION

Materials:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Story of BSE Student Handout</td>
<td>1 per student</td>
</tr>
<tr>
<td>BSE Town Hall Conversations Student Handout</td>
<td>1 per student</td>
</tr>
<tr>
<td>The Maddening Mystery of BSE Teacher Answer Key</td>
<td>1 per teacher</td>
</tr>
<tr>
<td>Detecting Mad Cow Disease article (see Preparation section for purchasing information)</td>
<td>1 per group (8 total)</td>
</tr>
<tr>
<td>Masking tape</td>
<td>1 roll</td>
</tr>
<tr>
<td>Measuring tape</td>
<td>1 per class</td>
</tr>
<tr>
<td>Pipe cleaners</td>
<td>2 per student</td>
</tr>
<tr>
<td>Optional: Pipe cleaners (for extension activity)</td>
<td>12 per group</td>
</tr>
</tbody>
</table>

Preparation:

- You may need to work with your school's biology teacher to ensure that your students have the necessary background knowledge of proteins for this lesson.

- Reserve a larger room (e.g., cafeteria or gym) or prepare to clear out your room for the activity. For a group of 20 students, you will need to mark out a defined 12’x12’ square that will serve as a “brain tissue” section for the lesson. Your students will be acting as prions within this space. We recommend that you use the masking tape to define the square. Cut the tape into 3’ segments and place them on the perimeter of the square. Optional: You will need to modify the square size to accommodate your class size, for example 8’x8’ for 10 students and 15’x15’ for 30 students.

- Print copies of the Student Handouts, 1 per student.

- Purchase a copy of the Scientific American article “Detecting Mad Cow Disease” at http://www.scientificamerican.com ($7.95). Search for the article title, and purchase the July 2004 issue to access the full article text. Print copies, 1 per group (8 total).

PROCEDURE

Day One

Preconceptions:

1. Engage students in a brief discussion to elicit their preconceptions about mad cow disease/BSE. What do they know about the disease? What have they heard in the news?

Hook:

2. Using your computer projection system, show a short news video about the most common human prion disease, Sporadic Creutzfeldt-Jakob Disease, from the following YouTube link:

vCJD Brain Killer Documentary (8:22 minutes)
http://www.youtube.com/watch?v=OE74S7fDDPc&feature=related
3. Distribute the Student Handouts, one copy of each Handout per student. Assign each of the students 1 of the 8 possible roles, as listed on The Story of BSE Student Handout. To prepare for the next class section, instruct students to read The Story of BSE Student Handout as a homework assignment. They will also need to complete the questions on the BSE Town Hall Conversations Student Handout that are specific to their assigned role. Depending upon the size of your class, you may need to modify the assignments to ensure that all eight roles are assigned to one or more students.

Day Two

Activity Procedure:

4. Start the class with a quick review of the movie clip. Ask the students if they recall whether those sick cows made humans sick? In their recollection, did the illness happen when they ate sick cows? Do they recall any recent cases of Bovine Spongiform Encephalopathy (BSE) or mad cow disease (such as the 2012 case in California)?

Activity #1: BSE Town Hall Conversations

Note: Students should have already read all Student Handouts before beginning this activity.

5. Organize the students into groups according to the role that they were assigned on the BSE Town Hall Conversations Student Handout. You should have eight student groups of varying size.

6. Using the BSE Town Hall Conversations Student Handout, have the students discuss their answers in their groups. Walk through the class and listen to the students’ conversations to determine student understanding.

7. After 5-10 minutes, bring the class back together and ask each group to present to the class their answers to the questions on the handout.

Activity #2: Prion Conversion Simulation

8. Explain to the class that scientists are just beginning to understand how animals become ill after they consume feed that contains animal products contaminated with proteins called “prions” (the most well known example is meat and bone meal). In well-studied diseases like salmonellosis, small, live organisms such as bacteria, viruses, or parasites cause illness when they destroy cells or the immune response fights the disease agent. Prions are different. They are not alive. They are merely proteins. The disease-causing, mis-folded PrPSc prions enter the animal, usually through feed, and when they get close to normal-PrPC prions their unusual folding structure causes normal-PrPC prions to mis-fold. This mis-folding converts them from normal-PrPC prions into disease agents: abnormal-PrPSc prions. After a typical incubation period of about 4-7 years, there will be increasing tissue degeneration, BSE symptoms, and eventually death. Tell students that their participation in the next activity will help them to gain a better understanding of how this process works.

9. Distribute pipe cleaners to students, one per student.

10. Each student should bend his pipe cleaner so that it roughly resembles the letter “C” to represent normal-PrPC prions. Select two students to act as abnormal-PrPSc prions. These two students should bend their pipe cleaners into the shape of the letter “S”.

11. Tell the students that you have prepared an area that will represent a slice of brain tissue within which will they will interact as normal and abnormal prions. Invite all the normal-PrPSc prions to enter the square. The students should be rather close together, but encourage them to hold their pipe cleaners out in front of them.
12. It is now time for the two PrP$^\text{Sc}$ prions to enter the square. Encourage them to navigate their way through the square. When they encounter a PrP$^\text{C}$ prion student, they must “transform” that student.

13. All PrP$^\text{C}$ prion students must try to stay within the square but avoid contact. But if they come into contact with a PrP$^\text{Sc}$ prion student, they must become a PrP$^\text{Sc}$ prion as well. This means that every PrP$^\text{Sc}$ prion student touched by a PrP$^\text{Sc}$ prion student must reform his pipe cleaner from a C to an S shape. Tell the students that this interaction represents the persuasive impact that abnormal prions have on normal prions once they come in contact.

14. Let this interaction run for 1-2 minutes. Then tell the students to freeze. Pause the simulation.

15. Ask students to look across the square.
   a. Count the number of PrP$^\text{Sc}$ prion students.
   b. Count the number of PrP$^\text{C}$ prion students.
   c. Assess the spaces between students in the square.

16. Tell them that these spaces represent the holes that gradually increase in size in prion-infected tissue. Emphasize that the activity they have conducted was designed to simulate the pathology we see in spongiform nerve tissues. In these cases, the increasing collection of PrP$^\text{Sc}$ prions leads to nerve cell death, eventually resulting in holes in the nerve tissue and ultimately, the animal’s death.

17. Restart the simulation for another minute. Eventually there will only be a few PrP$^\text{C}$ prions in the square. Tell the students that prion-related diseases generally take years to manifest, so the delay in the activity is similar to the real disease. You may invite the students to dramatize the ultimate death of the animal.

18. Ask students to return to their desks. Using your projection system, show the students a histology prep of spongiform tissue (available at the websites below). Remind the students that they just re-enacted the means by which abnormal prions interact with normal tissues, cause nerve cell damage and lead to the death of nerve cells and their subsequent removal by the immune system, which results in holes in animal brain tissue.

   **Histology Prep of Spongiform Tissue from BSE-affected Cows**
   The white spots are microscopic “holes” left by nerve cells that have died because of mis-folded prions.

   **vCJD Typical Amyloid Plaques**
   The structures with radiating hair-like filaments are prion “florid” plaques typically found in the brains of vCJD victims.

19. Ask the students to make notes in their journals regarding the following points and questions:
   - The FDA’s 2008 Enhanced BSE rule prohibits the use of **brain and spinal cord** material from cattle 30 months of age or older in any animal feed because PrP$^\text{Sc}$ prions concentrate in the central nervous system. This material must be labeled “Do Not Feed to Animals”.
   - Ruminants are food animals and can get prion diseases. To reduce the likelihood that humans ingest prions, the 1997 FDA “Ruminant Feed Ban” rule has prohibited the feeding of most mammalian protein (including brain and spinal cord) back to ruminants. This material is referred to as “Prohibited Material”. Feeds containing any prohibited material must be labeled “Do Not Feed To Cattle Or Other Ruminants”.

Mystery of BSE—6
20. At the end of the discussion, reinforce the point that a key role of WSDA, together with all other states and the FDA, is to regulate the safe manufacture and use of animal feed so as to limit BSE-related adverse events to animals and humans. In particular, students need to know that to achieve this FDA requires very specific Cautionary Statements to alert feeders about use limitations:

**Do Not Feed to Animals** = Material contains brain or spinal cord from cattle or buffalo 30 months of age and older. Cannot be used in feed. Fat (tallow) from this material cannot be used in feed unless residual protein is filtered out.

**Do Not Feed To Cattle Or Other Ruminants** = Material contains mammalian protein. Except, that the following proteins are exempt from this ban: Pure pork; pure horse; milk and milk products; blood and blood products; gelatin; inspected meat products cooked for human consumption and heated again; tallow with residual protein filtered out.

**Wrap-up:**

21. Tell the students that there are a number of neurological diseases that have been attributed to prions. We continue to learn more about the dietary, genetic, and environmental factors that make a person or animal more likely to get these diseases.

- **Optional:** Investigate a variety of prion-related diseases by reading aloud from the book *The Family that Wouldn’t Sleep* by D.T. Max (Chapter 10 *Apocalypse Cow* and Chapter 11 *Oinkies*). Direct the students to make notes on the data the specialists needed to collect to identify the cause of BSE and how British regulatory officials responded to the numerous BSE cases.

**Assessment Opportunities:**

- Review student preconceptions from the start of the lesson to determine students’ base understanding. Weight your subsequent work toward Activity #1 if students need a review of BSEs and how we control them, or toward Activity #2 if they need a stronger review of prions and their role in disease.

- Use the provided assessment rubric to assess students’ answers to the role questions on the BSE Town Hall Conversations Student Handout.

<table>
<thead>
<tr>
<th>Fails to Meet Expectations</th>
<th>Approaching Expectations</th>
<th>Meets Expectations</th>
<th>Exceeds Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not complete handout. Or, fails to proficiently complete at least 50%.</td>
<td>Attempts to complete handout, with &gt;50% proficiency regarding possible risks.</td>
<td>Completes most of handout, with &gt;70% proficiency regarding possible risks.</td>
<td>Completes most of handout, with &gt;90% proficiency regarding possible risks.</td>
</tr>
</tbody>
</table>

- Observe students’ participation in classroom activities (group work, group discussions, simulation activity, and any extension activities), noting: student participation, accuracy in portraying role, and ability to summarize newly gained knowledge when answering final questions.

- During the Protein Folding extension activity, review students’ pipe cleaner models for accuracy and degree of completion.
Extension Activities:

- Using your projection system, show students a variety of animations of prions as they convert from normal to abnormal, including:
  
  **McGraw Hill, How Prions Arise (1:29 Minutes)**
  
  [http://www.youtube.com/watch?v=m4VrTb1DVNw&feature=related](http://www.youtube.com/watch?v=m4VrTb1DVNw&feature=related)

  **The Institute of Molecular Biology & Biophysics, Prion Folding Animation**
  
  [http://tinyurl.com/7ongmnf](http://tinyurl.com/7ongmnf)

  **PrP Mis-folding and Aggregation Animation (0:32 minutes)**
  

  **Prions! Killer Proteins and Such (13:00 minutes, but start video clip at 5:32 minutes to see prion interaction)**
  
  [http://www.youtube.com/watch?NR=1&v=GuL8ScOVFaQ&feature=endscreen](http://www.youtube.com/watch?NR=1&v=GuL8ScOVFaQ&feature=endscreen)

- **Protein Folding Activity:** Hand out 2 pipe cleaners to each student. Using your projection system, display a cartoon structure of the PrP\(^\text{C}\) prion from the *Scientific American* prion article (available for purchase at [http://www.scientificamerican.com](http://www.scientificamerican.com)) or from one of the suggested video links. Instruct half of the students to bend the cleaners into the shape of the normal prion and half of the students to bend their cleaners into abnormal prions. Encourage them to be creative about their structures. Working in pairs, instruct the students to place the structures side by side and note in their journals the differences in the shapes of the two structures. Emphasize that you want them to note the differences in the molecules. **Optional:** Ask students to photograph their structures and include them in their class notebooks.

- Invite students to prepare research on other TSEs, such as Kuru, vCJD or Fatal Familial Insomnia (FFI).

- Discuss the fact that several government agencies are now monitoring internet activity, comments, and conversations as part of bioterrorism and public health efforts. For example, scientists use Google searches to track flu outbreaks through Google Flu Trends (available at [http://www.google.org/flutrends/us/#US](http://www.google.org/flutrends/us/#US)). What people email and post in social media or report in newspapers is being vigilantly monitored using computer programs for key terms such as “mad cow disease,” “BSE,” and “prions” in an effort to detect health challenges when they first begin. Show students the internet links provided in the *Resources* section of this lesson, such as Biocastor, Disease BioPortal, and HealthMap to make your point. Invite students to debate the appropriateness of government surveillance in protecting human health.

- The media plays a role in informing the public about best practices in the event of a health challenge. Invite students to conduct a web search on BSE, asking them to document their perceptions of the public’s passion regarding:

  a. The practice of feeding cattle rendered offal.
  b. The number of animals destroyed in the past to try to limit human illness.
  c. Animal husbandry practices where farmers breed sheep with genetic traits that are less susceptible to the prion disease scrapie. Selective breeding is the basis for USDA’s Scrapie Eradication program.
TEACHER BACKGROUND & RESOURCES

Career Links:

- Agricultural establishment inspector
- Animal feed producer
- Biochemist
- Cattle farmer
- Chemist
- Dairy farmer
- Epidemiologist
- Feedlot manager
- Feedmill operator
- FDA animal scientist
- Journalist
- Microbiologist, infectious disease specialist
- Neurobiologist
- Pathologist
- Physician
- Veterinarian
- Veterinary toxicologist

Background Information:

Bovine spongiform encephalopathy (BSE), commonly known as Mad Cow Disease, is a fatal neurological disease of cattle. BSE has a long incubation period, about 30 months to 8 years, but most cattle are affected four or five years after consuming contaminated feed. The disease may be most easily transmitted to human beings by eating food containing brain or spinal cord tissue from BSE infected carcasses. However it should be noted that the BSE prion, although most highly concentrated in nerve tissue, can be found in other cattle tissues but at much lower levels. Its presence does not always result in disease because BSE does not easily transmit to humans. The human form of BSE is now known as variant Creutzfeld–Jakob disease (vCJD). During the 20th century, many experts in agriculture, research, and policy worked together to describe the new disease agent, the new disease, and ways to protect public health and animal health.

B = Bovine = cattle
S = Spongiform = looks like sponge
E = Encephalo (brain) + pathy (disease) = degenerative disease of the brain
Resources:

Biocastor Project
http://born.nii.ac.jp/

CJD Brain Killer Documentary Video (8:26 minutes)
http://www.youtube.com/watch?v=OE74S7fDPc&feature=related

CDC About BSE
http://www.cdc.gov/ncidod/dvrd/bse/

Disease BioPortal
http://fmdbiportal.ucdavis.edu/

Google Flu Trends
http://www.google.org/flutrends/us/#US

HealthMap
http://www.healthmap.org/en/

Miller & Levine BSE links

Key Findings from the Phillips Report on the British Government’s Handling of the BSE Crisis

WSDA Animal Proteins & Cattle Materials Prohibited in Animal Feed
http://agr.wa.gov/FoodAnimal/AnimalFeed/Publications/ProhibMatDefs.pdf

WSDA BSE Prevention Inspections
http://agr.wa.gov/Foodanimal/AnimalFeed/#BSE

Wikipedia Commons Image of Bovine Spongiform Encephalopathy Tissue
http://commons.wikimedia.org/wiki/File:Histology_bse.jpg


Credit:

Lesson plan written by: Theresa Britschgi of the Washington Global Health Alliance; Tami Carabello of the Glacier Peak High School Science Department; and Jeffery R. Wehr of the Odessa High School Science Department.

Contributing authors: Kristen Bergsman and Joanna Prasertong.

Information on Transmissible Spongiform Encephalopathies (TSEs) and their control was provided by Evan Evans of the Washington State Department of Agriculture.

BSE illustration by Clayton DeFrate. Adapted from an illustration by the American Meat Institute.
The Maddening Mystery of BSE

A growing number of British farmers and veterinarians reported in the 1980s that their cattle and some zoo animals were exhibiting some very odd animal behaviors and signs—and some were dying. What was wrong with them? How did they get sick? Was there a risk that humans might start getting sick? What needed to be done at a national level to protect animals and humans alike?

In this activity, you will explore the discoveries and choices people made during the largest food scare of the twentieth century: Bovine Spongiform Encephalopathy (BSE). This new disease takes its name from:

\[ B = \text{Bovine} = \text{cattle} \]
\[ S = \text{Spongiform} = \text{looks like sponge} \]
\[ E = \text{Encephalo (brain)} + \text{pathy (disease)} = \text{degenerative disease of the brain} \]

As you read the essay below, you will use this **Student Handout** to guide your note-taking. The notes that you take will be specific to the role that you have been assigned. First, circle the role that you have been assigned:

- Beef Consumer
- Cattle Farmer
- Epidemiologist
- Feed Producer
- Journalist
- Pathologist
- USDA Inspector
- Veterinarian

Staggering BSE Cows

Beginning in the late 1970s, cows in England began suffering an assortment of unusual symptoms and behaviors, such as staggering, falling, and acting aggressively. Because these “staggering cows” were seen in counties far from one another and were attended by different veterinarians, cattle farmers did not see a suspicious pattern when an individual cow became ill. Usually, the sick cow was removed from the herd and sent for slaughter. Some of the meat from these sick cattle entered the human food chain while the slaughter byproducts (offal) were sent to renderers for processing into animal feed.

Renderers, often called the “oldest recyclers”, collect slaughter byproducts and dead animals which they grind and cook to make animal fat and meat and bone meal. The cooking kills bacteria, viruses and other usual pathogens which could be unsafe in animal feed. In the 1970s renderers were also using chemical solvents to extract the maximum amount of animal fat because the price of fat was higher than meat and bone meal. This process of “meat recycling” is a cost-effective way to increase the protein content of animal feed. At this time dairy and cattle farmers were using meat and bone meal in place of soybean meal, as a more affordable way to enrich animal feed.
In the early 1980s, a group of veterinarians began to take notice of the increasing number of erratic cows across Great Britain. In the pasture, these cows would tremble, stagger, and fall. If they could return to their feet, their steps were awkward and they would collapse. Alternatively, some formerly well-behaved cows would become anxious and aggressive. In 1983, the veterinarian Dr. Raymond Williams reported that a cow in Wiltshire, England kept to the extremities of her milking pen, progressively lost weight (even with a healthy diet), and was often too aggressive to be milked. Other local veterinarians such as Dr. David Bee and Dr. Colin Whitaker documented additional stories of staggering cows across England. They initially diagnosed the cause of the disease as a mineral or dietary imbalance. Veterinarians at the University of Bristol ran a number of tests and guessed that automated milking processes were agitating the dairy cows. Other veterinarians took tissue samples from deceased staggering cows and tested them for the presence of infectious organisms, such as fungus. The veterinarians interviewed the dairy farmers and farmers to look for common issues related to machinery, farm soil, or sick animal siblings, but none of these original theories held up to the collected clues and evidence.

Evidence Mounts that a New Animal Disease is Emerging

A few of the veterinarians managed to get some of the brain tissue of staggering cows to the government’s Central Veterinary Laboratory. Pathologists—disease detectives—noted significant holes in the brain tissue of the affected cows. Pathologists like Martin Jeffrey, who had previously worked with tissues from zoo animals with mysterious staggering symptoms, recognized the striking similarity between the tissues. Moreover, pathologists familiar with a sheep disease called scrapie also recognized the stereotypical holes in the brain tissue (see Figure 1). A sense of urgency arose: If the cause of this tissue abnormality could occur in several different species of animals, when would it occur in humans? What could be done to stop the agent from entering the human food chain?

First identified in sheep in Great Britain and other Western European countries more than 250 years ago, scrapie exists in North America and most European countries. Scrapie-infected sheep will usually show “maddening” symptoms such as behavioral changes, tremors, and declining coordination and ultimately death. Midway through the 20th century, doctors, veterinarians, and pathologists in the U.S. and England could see the similarity between scrapie sheep brain tissue and the brain tissue of those suffering from human neurological diseases such as kuru and Creutzfeldt-Jacob Disease (CJD). Kuru and CJD are known to cause a variety of abnormal neurological effects in humans, such as dementia, poor coordination, tremors, loss of speech, and personality changes. There was no evidence that eating sheep meat from scrapie-infected animals could cause CJD or kuru; but, with the emergence of BSE and the possibility it was caused by the sheep scrapie agent, as a precautionary measure the U.S. National Renderers Association in 1989 urged its members to voluntarily stop rendering sheep and goat material if their product was to be used in cattle feed.

It wasn’t until 1998 that Washington State University and United States Department of Agriculture (USDA) veterinary researchers such as Katherine O’Rourke announced that they had developed a practical test for testing living sheep for scrapie—even before the infected animals exhibited common scrapie symptoms. As of April 2012 there is no similar test for BSE.

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Figure 1: Micrograph of brain tissue from a BSE-affected cow showing the sponge-like appearance and the presence of vacuoles, or microscopic holes in gray matter. Source: Wikimedia Commons. From the Public Health Image Library, APHIS, 2003.
What was the Agent? Time to Discuss Prions!

In 1968, Dr. Carleton Gajdusek (a biomedical researcher and physician working for the National Institutes of Health) conducted a monumental experiment. His results led him to state in science publications that he felt that some novel, hard-to-destroy, “slow-virus” was the cause of all of these neurological diseases. This finding ultimately led to his receiving the 1976 Nobel Prize. Gajdusek’s experiments influenced the work of biochemist and physician Dr. Stanley Prusiner. Together, these men composed theories and conducted experiments that brought us our current understanding of Transmissible Spongiform Encephalopathies (TSEs) and prions.

Prusiner knew that the way to find the cause of TSEs was to get rid of all the distracting chemicals and molecules in tissue samples to find a molecule common to all the tissues—only then you would find the molecules responsible for the disease. Once he had that molecule, he would then be able to describe it fully with scientific tests. By 1981, his team was able to identify the molecule, and in 1982 he called this molecule a “prion.” According to Prusiner, a prion is a disease-causing agent that is **neither bacterial, fungal, nor viral**. It contains no genetic material and its overall functions cannot be altered by high heat and normal sterilization processes.

A prion can take more than one form or shape—in one form, the prion performs its normal functions on the surface of cells, including nerve cells. Scientists use the abbreviation PrP\(^C\) for the normal healthy prion. Once the function is complete, the prion gets disassembled and moved away. Disease-causing, abnormally shaped prions, called PrP\(^{Sc}\) interact with PrP\(^C\) prions and promote the conversion of PrP\(^C\) prions into PrP\(^{Sc}\) disease prions. These PrP\(^{Sc}\) prions clump together and “tangle” the PrP\(^C\) prions, converting them to an abnormal shape. This process is ultimately destructive to nerve cells which eventually die leaving behind the holes that are visible with an ordinary microscope. For BSE it usually about takes 4–7 years for this conversion process to show signs of illness in cattle; for humans with kuru it can take over 40 years.

Prions do not evoke a traditional immune response or inflammatory reaction in host animals. BSE is confirmed by **post-mortem** examination of an animal’s brain tissue using a test that can detect PrP\(^{Sc}\) prions if they are present. **BSE is not a contagious disease** and therefore is not spread through casual contact between animals. Scientists believe that transmission is through eating feed contaminated with tissue from a BSE infected animal.

There are a number of neurological diseases that have been attributed to prions. We continue to learn more about the dietary, genetic, and environmental factors that make a person or animal more likely to get these illnesses.

Protecting the Human and Animal Food Chain from the BSE prion.

In 1988, the *Daily Telegraph*, the first national daily to do so, reported the news of a mystery brain disease in British dairy cows. Journalist David Brown wrote of the “incurable ‘mad cow disease’ which riddled the brain with holes and drove docile animals berserk.”\(^1\) At the time, there were 32 confirmed and 96 suspected cases of British staggering cows and still no regulatory efforts to keep possibly contaminated meat out of the food chain. It was a new and complicated disease and


DNA is the instructions for life. The cell uses specialized tools, called enzymes, to ‘interpret DNA’ into another molecule called RNA (ribonucleic acid). Another set of enzymes ‘interprets’ the RNA molecule into a string of amino acids. The amino acids then self-assemble by folding themselves up into what we call a protein. If DNA is the instructions for life, then proteins are the tools that get the job done.

The ability of proteins to self-assemble into shapes that have a function is an extremely important ‘skill.’ These shapes are determined by the properties of the amino acids and their order in the string. Amino acids vary in size and charge and so the string will bend and twist to resolve the effects of size and charge amongst the amino acids. Normally there is only one or a small number of ‘stable’ ways the protein can have its amino acids’ shapes and charges resolved. This results in the same piece of DNA being able to make the same protein with the same shape, structure and function over and over again reproducibly.
neither farmers nor politicians wanted to impact the British beef industry without concrete evidence of the cause of the disease and a clearer sense of the threat to human health. They hesitated to change practices for three reasons:

1. Prion research was young.
2. The disease was not being discussed in the general press.
3. Conversations between farmers and researchers were time-consuming as they looked at the many ways the cows could have been exposed to prions (through feed, in the soil, via contaminated surfaces/equipment, and variability in housing).

The inconsistent paperwork and records of the beef and dairy farmers did not help matters. The disease epidemiologists noticed that many of the farmers stated in their paperwork, “cake in parlour.” Cows enjoyed this high protein, molasses-sweetened supplement as they were being milked (in the “parlour”). More than molasses, the cake was also rich with rendered animal meat and bone meal. Calves were also fed rations supplemented with meat and bone meal to get them into production faster. Epidemiologists interviewed the renderers to find out what had changed in their production lines over the past five years—the time when British farmers were seeing the most staggering cows. What they learned was striking.

During the 1970s two economic drivers came together to change traditional British rendering practices. The price of animal fat declined and the cost of energy went up. There was no longer a business incentive to maximize fat production so renderers stopped using chemical solvents which in turn allowed them to reduce the duration and temperature of the cooking process thereby using less fuel. Finally, during this time the cost of soybean and fish meal rose causing cattle farmers to increasingly use meat and bone meal in place of these more expensive protein sources. Taking these factors into account, British officials could now see why their farmers, as compared to farmers in other countries, were seeing more staggering cows. It was time to act on their findings.

In 1988 the British government imposed a ban on feeding ruminant-derived protein to other ruminants. Additionally, they forbade cattle farmers from selling cattle obviously ill with BSE. Funding was provided to slaughter and dispose of the sick cows and to compensate farmers for their loss. By 1990, a handful of pets and zoo animals were diagnosed with spongiform encephalopathy. After reports of an ailing cat named “Mad Max” were cited in the news, school districts banned British beef from school cafeterias.

Cattle cases and new clues grew, as did public anxiety. Headlines such as “The Mad Cow Deceit”² and a series of illnesses and deaths reported in teens ultimately persuaded British officials that British beef was linked to a spectrum of neurological diseases. Later, a law banning all animal protein in cow feed was implemented in England. A second British law would eventually ban animal protein in all British animal feed. Meanwhile, the British government ordered the slaughter of 3.3 million cattle that might have been exposed to prions (including siblings or animals that shared a common food source) at a cost of billions of pounds.

Afterword: Protecting Americans from BSE

The British BSE challenges associated with feeding cattle meat and bone meal that contained BSE-infected products peaked in January 1992 with almost 1,000 new cases a week. In total, 184,500 BSE cases were found in 35,000 herds. It is estimated that 1.6 million BSE-infected animals entered the British human food chain before regulatory controls were introduced.

The USDA regulates the importation of animals and animal products to protect the health of U.S. livestock. Because vCJD in humans has been linked to exposure to the BSE agent, the USDA collaborates with other federal agencies, such as the FDA, with regulatory responsibility for assuring food safety and the protection of human health, to implement a comprehensive coordinated U.S. response to BSE. The Centers for Disease Control and Prevention (CDC) ultimately coordinate the

response to vCJD. What truly protects human and animal health and the $11.9 billion U.S. beef trade (2011 estimate) is the system of interlocking safeguards shown in Figure 2, including all of these elements:

- The U.S. allows imports only from countries that have an equal or lower BSE risk.
- The BSE surveillance programs test for the presence of BSE in the population of cattle that, due to age or health status, is at the highest risk for having the disease. Such tests are conducted post-mortem and tell us how prevalent BSE is in the U.S. (BSE testing itself is not a food safety measure—it tells us what kind of food safety measures we need based on how big the threat is.)
- Removing from the human food chain tissues that studies have shown to contain the highest amounts of BSE agents. Such tissues, called “Specified Risk Materials” (SRMs), are required by the USDA to be excluded from human food. In general, these SRMs include brain, skull, eyes, spinal cord, and vertebral column, the terminus of the small intestine, and the tonsils.
- BSE animal feed ban rules, including:
  * In 1997, the FDA banned the use of most mammalian proteins in feed for cattle and other ruminants (exceptions include: blood and blood products; milk and milk products; gelatin; pure pork or pure horse meat; and inspected meat products, such as plate waste, which have been cooked and offered for human food and further heat processed for animal feed). Mammalian protein banned from ruminant feed is called “Prohibited Material” and feeds, except pet food, that contain “Prohibited Material” must be labeled “Do Not Feed to Cattle or Other Ruminants.”
  * The FDA’s 2008 Enhanced BSE Rule prohibited the use of brain and spinal cord from cattle and buffalo 30 months of age and older in all animal feed. This material must be labeled “Do Not Feed to Animals.” This rule also regulates animal fat from cattle to be sure it is protein-free if used in ruminant feed.
- Tracing and tracking systems for live animals, human food, and animal feed.

The combined safeguards listed above protect U.S. citizens from acquiring vCJD and protect U.S. herds from contracting BSE.

**How many cases of BSE have been found in the United States?**

USDA has been testing for BSE since 1990. As of April 2012, only four cows in the U.S. have been found positive for BSE.

The very first case in the entire U.S. was identified in 2003 in Moses Lake, WA, by a WSDA Field Veterinarian. The ensuing international investigation traced the BSE positive cow back to a Canadian herd. Since this animal was exposed to BSE contaminated feed while still in Canada it is no longer counted as a native U.S. BSE case. USDA and WSDA experts used livestock tracking systems and DNA matching to prove the Canadian origin.

Three other BSE positive cattle have been identified since 2003 but none of these had the feedbourne “classical” BSE—the kind that was epidemic in the U.K. and other European countries. The other three cases had “atypical” strains of BSE which are not believed to be caused by contaminated feed. Atypical BSE seems to be a very rare old-age disease of cattle similar to human old-age dementias like Alzheimer’s disease. The cause is not known. The atypical cases were found in Texas—2005, Alabama—2006, and California—2012.

Countries with the ability to detect the rare atypical forms of BSE are considered to have very robust surveillance programs.
**Figure 2:** Strategies for protecting the U.S. food supply from BSE. **Credit:** Clayton DeFrate.

PROTECTING THE U.S. FOOD SUPPLY FROM BSE

**U.S. Borders**

U.S. FDA Consumer Safety Officers check imported food, cosmetics, pharmaceuticals, and feed ingredients for compliance with BSE regulations. U.S. Customs Border Patrol – Agriculture Specialists check imported meat products not regulated by FDA and live animals for compliance with BSE regulations.

**Feed Mills**

FDA and State Departments of Agriculture inspect feed mills, feed haulers, and other firms, such as human food processors, that produce waste products used for feed. Most mammalian protein cannot be fed to ruminants*. Any feed containing these BSE prohibited materials must be labeled “DO NOT FEED TO CATTLE OR OTHER RUMINANTS”.

**Dairies & Feedlots**

Dairies and feedlots are also inspected by states and FDA to be sure that the feed does not contain prohibited materials. The owners may have their feed suppliers provide written assurance they will not deliver any feed with ingredients that could spread BSE.

**Rendering Plants**

These plants are inspected by states and FDA. Renderers are called the “oldest recyclers” because they process animal tissue that would otherwise be discarded. Renderers cook animal tissue from slaughter plants and other sources to kill most pathogens (but not the BSE infective agent). Renderers make Meat & Bone Meal and animal fat. Meat & Bone Meal from most renderers cannot be fed to ruminants so it must be labeled “DO NOT FEED TO CATTLE OR OTHER RUMINANTS” when it is shipped.

**Human Health Safeguards**

The human form of BSE is vCJD which can be transmitted by blood. To safeguard against the spread of this fatal disease, the FDA cannot accept blood donations from people who have lived in countries that have had BSE epidemics.

**Slaughter & Meat Packing Plants**

These facilities only purchase animals certified by the owner as never having been fed any BSE-prohibited materials. USDA veterinarians make sure certain tissues (e.g., Specified Risk Materials, SRMs) that could harbor BSE agents are removed from human food.

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* *Ruminant animals include cattle, sheep, goats, deer, and elk.*
**BSE Town Hall Conversations**

**Student Handout**

**Homework:** After reading *The Story of BSE* Student Handout, read the questions in the table below that are particular to your assigned role. Record your answers to these questions on a separate piece of paper.

**Next Class Session:** You will break into teams representing all 8 roles and participate in a “town hall” conversation on the history of TSE diseases, how it has impacted the animal and human food industry, and the means by which state and federal officials protect animals and the public.

<table>
<thead>
<tr>
<th>Role</th>
<th>Questions</th>
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| **Beef Consumer**           | 1. Before today’s lesson, did you know that animals eat feed from recycled animal products? With restricted resources and a growing human population, do you think recycling animal products is good or bad?  
2. Based on today’s reading, when do you think consumers should be informed about possible issues related to the meat that they eat?  
3. Name one way that the journalists intensified public anxiety about British beef. |
| **Cattle Farmer**           | 1. Why did the cattle farmers use meat and bone meal in their dairy cow feed?  
2. Discuss why a cattle farmer would want to know if his cow had BSE. Why might a farmer not want to know if their cow had BSE?  
3. As a consequence of the FDA ruminant feed ban, what kind of mammalian proteins can cattle farmers feed their ruminant animals such as cattle, sheep, goats, and buffalo? |
| **Epidemiologist**          | 1. Name two questions that an epidemiologist might pose to determine how an animal contracted BSE.  
2. Veterinary epidemiologists deal with the investigation of diseases, productivity, and animal welfare in populations. They collect and analyze field data. Name two patterns in meat and bone meal preparation that the epidemiologists noticed in their investigation and were key to identifying the source of the disease.  
3. Explain why you think epidemiologists get trained in both animal and human diseases. |
| **Feed Producer/Meat Renderer** | 1. How did rising energy costs contribute to the British BSE challenge?  
2. How did lower prices for animal fat contribute to the British BSE challenge?  
3. How did the price that farmers wanted to pay for protein contribute to the British BSE challenge? |
| **Journalist**              | 1. List the two reports and news articles discussed in the reading.  
2. Discuss why a journalist would describe a cow with BSE as “mad.”  
3. Discuss how a journalist without a background in science would investigate a community health challenge accurately when the health and science community had not yet determined the cause of the health issues. |
| **Pathologist**             | 1. A prion is a sub-microscopic molecule. How were pathologists able to see the relationship between scrapie sheep and BSE cattle?  
2. U.S. scientists were developing prion theories while British pathologists were developing a theory about the link between BSE cows and feed practices. Eventually they discovered that the abnormal prions changed normal prions into abnormal proteins. How did this conversion lead to holes in nerve tissue?  
3. British officials first implemented BSE regulations in 1988. If you had cattle brain tissues from 1990 and from 2004, which sample would be more likely to have BSE pathology? |
### USDA Inspector
1. What type of cattle do inspectors test for BSE?
2. When an inspector visits a cattle slaughterhouse, she/he might anticipate seeing the meat cuts moving into three possible paths: for human consumption/“edible,” offal for rendering into animal feed, and the “Do Not Feed to Animals” container. Into which path would they expect to see Specified Risk Materials (SRM)?
3. When an inspector visits a cattle slaughterhouse, she/he might anticipate seeing the meat cuts moving into three possible paths: for human consumption/“edible,” offal for rendering into animal feed, and the “Do Not Feed to Animals” container. If this facility only slaughtered swine, which path would they expect to see swine slaughter parts go into?

### Veterinarian
1. Discuss the conflict a veterinarian might feel when a BSE diagnosis results in the destruction of the suspect animal.
2. British veterinarians report their BSE cases to the Ministry of Agriculture, Fisheries, and Food (MAFF). To what agency should a Washington State veterinarian report a potential BSE case? To what agency would a doctor ultimately report a case of vCJD?
3. You are a veterinarian, not an inspector. If you see a bag of feed labeled “Do Not Feed to Cattle or Other Ruminants” in a dairy farmer’s barn, should you be alarmed?

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After reviewing your answers as a group, develop as a group an answer to the following summary questions:

1. Discuss whether you would have eaten a British burger in 1986. Would you have eaten a British burger in 2004? Explain your reasoning for both situations.
2. Name three current practices in place in the U.S. that ensure that Americans can safely eat burgers made from U.S. cattle.
3. Why is it acceptable for some animals to eat animal feed made with meat and bone meal?
4. Name the two references to Washington State in the reading.
Lesson Plan—Preconception Questions:

- Ask the students if they recall whether those sick cows made humans sick. In their recollection, did human illness happen when they ate sick cows?

  Scientists and experts believe the new disease of young adults, vCJD, was caused by eating food products that contained tissues, especially central nervous system tissue (brain and spinal cord) from cattle that had BSE. From the time the new cattle disease, BSE, was described it was another ~10 years before the new human disease, vCJD, was identified.

- Do they recall any recent cases of Bovine Spongiform Encephalopathy (BSE) or mad cow disease?

  Student answers will vary. The most recent case was identified in April 2012 in a California dairy cow.

BSE Town Hall Conversations—Homework Questions:

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<tr>
<th>Role</th>
<th>Questions</th>
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| Beef Consumer   | 1. Before today’s lesson, did you know that animals eat feed from recycled animal products? With restricted resources and a growing human population, do you think recycling animal products is good or bad? Answers may vary.  
2. Based on today’s reading, when do you think consumers should be informed about possible issues related to the meat that they eat? Answers may vary.  
3. Name one way that the journalists intensified public anxiety about British beef. When the journalists discussed teen cases or Mad Max, the public was less interested in eating British burgers. |
| Cattle Farmer   | 1. Why did the cattle farmers use meat and bone meal in their dairy cow feed? Dairy farmers added the high protein found in meat and bone meal to their feeds to increase the quantity of milk they could sell. They used meat and bone meal over other protein sources because it cost less. They also added it to calf feed so they would come into production faster.  
2. Discuss why a cattle farmer would want to know if his cow had BSE. Why might a farmer not want to know if their cow had BSE? A farmer would want to know what was wrong with a sick cow to protect the rest of the herd, because they are compassionate, or because they need to know what market should receive his meat (animal or human). A farmer might not want to know if his cow had BSE because this animal and others on his farm would be slaughtered.  
3. As a consequence of the FDA ruminant feed ban, what kind of mammalian proteins can farmers feed their ruminant animals such as cattle, sheep, goats, and buffalo? Blood and blood products; milk and milk products; gelatin; pure pork or pure horse meat; and inspected meat products, such as plate waste, which have been cooked and offered for human food and further heat processed for animal feed. |
### Epidemiologist

1. Name two questions that an epidemiologist might pose to determine how an animal contracted BSE.
   - What did the animal eat?
   - How was the animal’s feed prepared?
   - Have other animals eaten this feed? What is their health status?
   - How old is the animal?
   - Where did the animal come from – domestic herd or from another country?

2. Veterinary epidemiologists deal with the investigation of diseases, productivity, and animal welfare in populations. They collect and analyze field data. Name two patterns in meat and bone meal preparation that the epidemiologists noticed in their investigation that were key to identifying the source of the disease.
   - Once they established a connection between the sick animals and a specific feed ingredient, the epidemiologists were able to direct their attention towards the preparation of meat and bone meal. They interviewed renderers and noticed patterns of change in the use of chemical solvents and the time and temperature of the cooking process.

3. Explain why you think epidemiologists get trained in both animal and human diseases.
   - Many human diseases originate in animals. Many animal disease pathologies can resemble human disease pathologies.

### Feed Producer/Meat Renderer

1. How did rising energy costs contribute to the British BSE challenge?
   - Renderers reduced both the duration and temperature of the rendering process to reduce fuel costs. Heat does not kill prions but the longer exposure to higher temperatures of the old process probably reduced infectivity—especially when combined with chemical solvents.

2. How did lower prices for animal fat contribute to the British BSE challenge?
   - Renderers stopped using chemical solvents because it became less profitable to maximize animal fat extraction using chemical solvents, which required higher temperatures and longer cooking. Many experts believe this combination was enough to keep the BSE prion in check.

3. How did the price that farmers wanted to pay for protein contribute to the British BSE challenge?
   - Farmers could pay a lower price for protein in meat and bone meal than the price that they would pay for protein from soy and other sources. This created a strong market for the use of meat and bone meal from rendered offal.

### Journalist

1. List the two reports and news articles discussed in the reading.
   - “Incurable Mad Cow Disease” and “The Mad Cow Deceit.”

2. Discuss why a journalist would describe a cow with BSE as “mad.”
   - Answers will vary, but should include the fact that ill animals acted aggressively and seemed “out-of-control” or reflect the journalist’s desire to have a sensational article. **Note:** The first hint of the nickname came from a report in January 1985 by the veterinary investigative officer who visited a suspect farm. The “cow went mad and aggressive,” the official noted.

3. Discuss how a journalist without a background in science would investigate a community health challenge accurately when the health and science community had not yet determined the cause of the health issues.
   - Answers will vary, but should include conducting interviews, reading science articles, and visiting the library. Overall, the student should be encouraged to state that it is hard!
| **Pathologist** | **1. A prion is a sub-microscopic molecule. How were pathologists first able to see the relationship between scrapie sheep and BSE cattle?**  
British veterinary pathologists who were familiar with the typical spongiform change observed in scrapie-affected sheep brains and those familiar with spongiform brain tissues mysteriously appearing in zoo animals recognized the analogous “brain holes” in the brain tissue samples from cattle dying of a new disease, later named BSE.  
2. **U.S. scientists were developing prion theories while British pathologists were developing a theory about the link between BSE cows and feed practices. Eventually they discovered that the abnormal prions changed normal prions into abnormal proteins. How did this conversion lead to holes in nerve tissue?**  
This process is ultimately destructive to nerve cells, which eventually die leaving behind the holes that are visible with an ordinary microscope.  
*Note:* The precise mechanism of cell death in prion diseases is not well defined. The “holes” are specialized membrane bound structures called vacuoles in which cell organelles, proteins, and other intracellular contents are subjected to enzymatic digestion.  
3. **British officials first implemented BSE regulations in 1988. If you had pathology tissues from 1990 and from 2004, which sample would be more likely to have BSE pathology?**  
At the beginning of the BSE epidemic in the UK, ~1985, most cattle became ill at age 4 or 5 years. In 1990, many cattle could have been fed BSE contaminated feed before it was banned. Thus, by 1990, many cattle could be showing the signs of BSE in pathology tissues. By 2004, the feed ban effectively stopped most exposure to the BSE infective agent so these tissues would be much less likely to show BSE spongiform change. |
| **USDA Inspector** | **1. What type of cattle do inspectors test for BSE?**  
Cattle exhibiting erratic, anxious, aggressive, or staggering behavior; older cattle; cattle that cannot get up known as “non-ambulatory” or “downers.”  
2. **When an inspector visits a cattle slaughterhouse, she/he might anticipate seeing the meat cuts moving into three possible paths: for human consumption/“edible,” offal for rendering into animal feed, and the “Do Not Feed to Animals” container. Into which path would they expect to see Specified Risk Materials (SRM)?**  
Some SRM materials would go into the paths for rendering and be labeled “Do Not Feed to Cattle or Other Ruminants;” brain and spinal cord would go to non-feed use and be labeled “Do Not Feed to Animals.”  
3. **When an inspector visits a cattle slaughterhouse, she/he might anticipate seeing the meat cuts moving into three possible paths: for human consumption/“edible,” offal for rendering into animal feed, and the “Do Not Feed to Animals” container. If this facility only slaughtered swine, which path would they expect to see swine slaughter parts go into?**  
Edible parts would go into the path for human consumption; “offal” would go to rendering. Since the USDA SRM rule only applies to cattle and buffalo, and pure pork material is exempted in the FDA Ruminant Feed Ban rule—inedible slaughter byproducts could be rendered into “Pure Porcine Meat and Bone Meal” and used in feed for all species. |
Veterinarian  |  1. Veterinarians make a living treating animals and promoting the health of their client’s animals. Discuss the conflict a veterinarian might feel when a BSE diagnosis results in the destruction of the suspect animal.

Answers will vary. Some students may appreciate the need to euthanize suspect animals to protect the food supply. Others may state that they would have a hard time euthanizing suspect animals. Veterinarians will feel compassion for the individual animal but will balance this feeling with their responsibility to prevent illness and suffering in other animals and humans.

2. British veterinarians report their BSE cases to the Ministry of Agriculture, Fisheries, and Food (MAFF). To what agency might a veterinarian in Washington State report a potential BSE case? To what agency would a medical doctor ultimately report a case of vCJD?

Washington veterinarians would report suspect BSE cases to the USDA. Medical doctors would report potential vCJD cases to the CDC. Coordination and communication must occur between these agencies to limit the extent of the disease challenge.

3. You are a veterinarian, not an inspector. If you see a bag of feed labeled “Do Not Feed to Cattle or Other Ruminants” in a dairy farmer’s barn, should you be alarmed?

You should be alarmed if:

- You witness the banned feed being added to the dairy feed.
- If the bag spills on top of the hay used to feed the cows.
- If the dairy farmer is only raising cows.

But, you need not be alarmed when this feed is present if this dairy farmer is using the feed only to feed chickens or other non-ruminants also being raised on the farm.

BSE Town Hall Conversations—Summary Questions:

After reviewing your answers as a group, develop as a group an answer to the following summary questions:

1. Discuss whether you would have eaten a British burger in 1986. Would you have eaten a British burger in 2004? Explain your reasoning for both situations.

Answers will vary. Some groups will have a number of vegetarians or newly spooked kids who will state that they will never eat burgers! Others might state that they would not eat a 1986 burger but with the new regulations and rules they might eat the 2004 burgers. It is possible that some might state that they do not believe in prions, as was common in the 20th century, and therefore would have no qualms about eating burgers of any vintage.

2. Name three current practices in place in the U.S. that ensure that Americans can safely eat burgers made from U.S. cattle.

The safety precautions include any three of the following practices:

- The removal of specified risk materials from the human food chain.
- The FDA’s BSE animal feed ban rules.
- BSE surveillance.
- Import restrictions
- The ability to track live animal movements and to trace animal feeds from manufacturer to end user is not a primary protection but is key to rapid containment and control food/feed safety events.
3. Why is it acceptable for some animals to eat animal feed made with meat and bone meal?

Other animals raised for food such as swine, poultry, and fish do not get TSEs even though they routinely eat feed with intentionally added meat and bone meal that is prohibited in ruminant feed.

4. Name the two references to Washington State in the reading.

- The first case of BSE in the entire U.S. was identified in Moses Lake, WA in 2003 by a WSDA Field Veterinarian. This animal was traced back to a Canadian herd which is where it was exposed to the contaminated feed.
- USDA scientists in Pullman, WA, working with Washington State University scientists developed a test for scrapie that could be used for living sheep before they showed any signs of sickness.

Lesson Plan—Prion Conversion Simulation Questions:

- Describe the difference between PrP<sup>Sc</sup> and PrP<sup>C</sup> prions. How was this demonstrated in the simulation?

Prions are proteins. The difference between PrP<sup>Sc</sup> and PrP<sup>C</sup> prions is their shape. PrP<sup>C</sup> prions are found in healthy nerve tissue. Misshapen PrP<sup>Sc</sup> prions cause disease. Meat and bone meal made from BSE infected cattle can carry PrP<sup>Sc</sup> prions into healthy cattle through feed. PrP<sup>Sc</sup> prions then spread from the gut to the brain. The students that acted like abnormal PrP<sup>Sc</sup> prions transformed the shapes of the pipe cleaners held by the normal-PrP<sup>C</sup> prion students—causing them to take on the abnormal PrP<sup>Sc</sup> prion shape.

- Prions “transform” rather than “infect” healthy tissue. Describe how this was demonstrated in the simulation.

Abnormal-PrP<sup>Sc</sup> prions enter the animal and when they get close to normal-PrP<sup>C</sup> prions, their unusual folding structure misfolds the normal prions. The students that acted like PrP<sup>Sc</sup> prions were able to “change” normal-PrP<sup>C</sup> prions/students by causing them to bend their pipe cleaners into a different shape. Then the normal prions moved away.

Extra: In reality, the normal prions do not move away—they are converted to abnormal prions. The abnormal prions aggregate. The converted prions lose their normal function, gain toxicity, and ultimately result in the death of nerve cells.