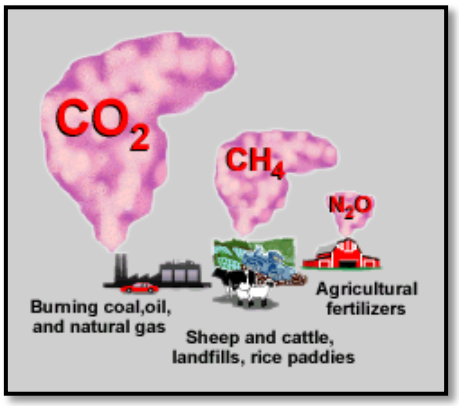
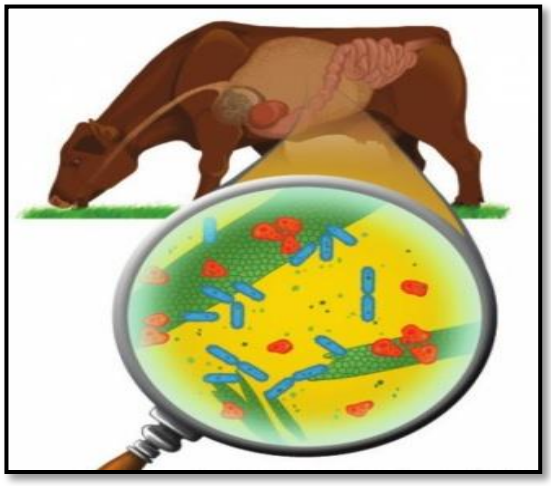
Student Sheet 1

CRITICAL THINKING ACTIVITY: A LIVESTOCK DILEMMA



Methane is the second most significant greenhouse gas and cows are one of the greatest methane emitters. Their grassy diet and multiple stomachs cause them to produce methane, which they exhale with every breath. There are currently approximately 1.3 to 1.5 billion cows grazing, sleeping, and eating at any given time on planet Earth. These 1,300-pound (average weight for both a beef and dairy cow) animals eat a lot. Much like humans, when they eat, gas builds up inside of their guts and has to be expelled. The result is a large amount of methane being introduced into the atmosphere.



Cows are ***ruminant*** animals- animals that chew their cud and have split hooves. This group includes domestic cattle, bison, buffaloes, camels and llamas, giraffes, deer, pronghorns, antelopes, sheep, and goats. Most ruminants have four stomachs, two-toed feet, and store their food in the first chamber of the stomach, called the ***rumen***, before regurgitating or bringing it back up. This food is called "cud" and the animals chew it again to help further break it down and make it easier to digest. Inside of the rumen, over four hundred different kinds of ***microbes*** exist that also play an important role in the digestion process. Several of these microbes create methane gas as a byproduct. Due to the number of cows on the planet, along with the large size per cow, cows produce more methane gas than all other ruminants combined.

Student Sheet 2

Livestock, like automobiles, are a human invention and convenience, not part of pre-human times. A molecule of CH_4 exhaled by livestock is no more natural that a molecule of CO_2 from an auto tailpipe. Today, tens of billions more livestock are exhaling CH_4 than in preindustrial days, while Earth's ability to keep carbon out of the atmosphere through photosynthesis, has declined sharply as ***forest and natural grasslands*** have been cleared. For example, 150 years ago much of the Midwest in the United States was still covered with chest-deep prairie grassland. This grassland provided valuable food and habitat for billions of plant and animal species, including millions of elk, bison and deer. These lands also supported natural environmental processes including ***carbon sequestration.*** This ***symbiotic system***, which evolved over millions of years, is what sequesters carbon naturally and keeps the planet habitable. In fact, destroying grassland ecosystems, and the carbon sequestration they sustain, could possibly be as damaging to life as clear-cutting the rainforest.

Methane emissions from the digestive processes in ruminant animals, including cattle, sheep and wild animals, is estimated to provide an atmospheric source of 87-94 Tg **(a million million grams)** per year. Methane emissions depend upon the number and type of animals and the type of food. In order to feed this massive influx of cows that naturally growing grass and flowers could no longer handle, pastures have been reseeded with perennial ryegrass. This grass lacks the nutrients and is difficult to digest, which causes even more methane gas to be expelled.

Scientists are actively monitoring CH_4 emissions from ruminants and have experimented with diet, vaccines and other methods to see if that could help cut down on the emission of CH_4 gas. Several different solutions have been proposed. For example, a better quality feed, such as grain or feed with low fiber (fresh grass, alfalfa), will digest easier, increase feed efficiency and lower CH_4 and waste production. Researchers in Manitoba, Canada have found that there were 50% less CH_4 emissions from grazing steers with access to high quality pastures.

Student Sheet 3

We cannot deny that farming has a major impact on global warming. Since farming is basically serving the consumer's demand for food, we should also look at our diet. With increased prosperity, people are eating more meat and dairy products every year. Global meat production is projected to more than double from 229 million tons in 1999/2001 to 465 million tons in 2050, while milk output is set to climb from 580 to 1043 million tons.

Many suggestions have been offered as to methods for reducing these numbers. Members of the United Nation's climate science panel, have called on people to eat less meat. With greenhouse gas emissions from sheep and cattle 19 to 48 times greater than beans or grains per pound of food produced, something that sounds as outlandish as a tax on meat may actually be not only common sense but necessary if we are going to be serious about fighting climate change. Just like taxes on sugar, fat and soda, a tax on meat is a measure meant to get humans to, like it or not, change their ways.

Student Sheet 4

DATA TABLE 1: METHANE RELEASE FROM COWS #233 AND 54

COW #233			COW #54		
SAMPLE #	CH_4 Released g/d	g/hr	SAMPLE #	CH_4 Released g/d	g/hr
1	82		1	2	
2	120		2	47	
3	NA		3	NA	
4	182		4	NA	
5	111		5	137	
6	67		6	141	
7	223		7	NA	
8	213		8	NA	
9	172		9	NA	
10	164		10	NA	
11	189		11	NA	
12	158		12	NA	
13	165		13	NA	
14	134		14	224	
15	NA		15	220	
AVERAGE			AVERAGE		

Student Sheet 5

DATA TABLE 1:METHANE RELEASE FROM SHEEP 0036/0038

SHEEP #0036 SHEEP #0038

SAMPLE #	CH_4 Released g/d	g/hr	SAMPLE #	CH_4 Released g/d	g/hr
1	22.7		1	10.8	
2	22.5		2	23.3	
3	24.6		3	23.6	
4	26.8		4	14.3	
5	24.5		5	19.5	
6	17.7		6	21.4	
7	23.1		7	12.0	
8	13.9		8	13.6	
9	36.7		9	18.5	
10	30.8		10	13.2	
11	17.1		11	18.0	
12	24.3		12	17.6	
13	18.4		13	13.2	
14	13.6		14	19.5	
15	12.8		15	11.6	
AVERAGE			AVERAGE		

Student Sheet 6

ANALYSIS

1. What type of scientists are measuring methane emissions from cows and sheep?
2. What country do these scientists represent?
3. What are the 2 objectives of the study?
4. How is methane produced and emitted by ruminant animals?
5. What part of the national methane emission is produced by ruminant animals in New Zealand?
6. Why is this fact unusual?
7. How could the national methane emission be used?
8. Explain how the measurement apparatus works
9. What compound is used as a tracer in this process?
10. How is the methane rate calculated?
11. What type of animals and how many of each are used in this study?
12. What else is studied in addition to the breath analysis?
13. What was the average amount of methane emitted by the cows?
14. What was the average amount emitted by the sheep?
15. Why would you think that the data for Cow #54 was not helpful?
16. What could have caused this to happen?
17. Which study group probably had fewer problems during the test?
18. Animal nutrition specialists know that a higher in protein then food is, the less methane is produced. How could this be helpful in lowering methane emissions?
19. Even though New Zealand's contribution to global warming is not CO_2, why should they be concerned about methane emissions?

APPLICATION:

1. Design a method for sampling ruminant animal breath and/or fecal matter that would be simple to use, reliable and safe for the animal?

2. The last paragraph of the background sheet you discussed with your teacher and the class mentions reducing the amount of meat we eat or not eating it at all. Do some research into this issue and prepare a presentation either defending or refuting this claim. Be sure to provide ample data to support your conclusions.

"Sheep's breath: How sweet thou art!" (by K.Lassey, NIWA)

A team of NIWA atmospheric scientists, in collaboration with scientists from AgResearch at Massey, Palmerston North, have been literally "out in the field" measuring methane respired by grazing livestock, notably sheep. The objective is to measure daily methane emissions from individual ruminant animals and ascertain the extent of variation among them. Methane is generated microbially in the rumen and belched during digestion.

New Zealand's livestock are believed to produce 80% of national methane emissions, with sheep accounting for more than half of the livestock emissions. New Zealand is unusual among developed countries in having a larger contribution from methane than from carbon dioxide to the national CO_2 equivalent greenhouse gas emission. In fact, the national methane emission would be sufficient to power the entire North Island domestic car fleet, converted to run on CNG (compressed natural gas) for about 12,000 km per year.

This sampling technique was first tried a year ago by the NIWA/AgResearch team in collaboration with its U.S. developers. A lightweight apparatus mounted on each animal continuously breathalizes the animal at a rate of less than 1 mL per minute through a 24 hour sampling period. The technique is calibrated using a source of inert tracer previously inserted into the rumen of each animal. The trace, ***sulfur hexafluoride (SFl_6)*** is released from a small capsule through a permeable membrane. Breath samples are analyzed for methane and sulfur hexafluoride using gas chromatography, and the methane production rate is calculated from their concentrations in excess of background and the rate of release of sulfur hexafluoride.

Five daily samples are collected from each of 50 sheep and 10 dairy cows. In parallel with this, AgResearch scientists collect and analyze fecal material from each animal to provide a measure of feed intake, to which the production of methane can be related.