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Theme 2 “At The Farm”
Further information and references sheet 1 of 3, for TakeABiteAtHome

TAKE A BITE OUT OF CLIMATE CHANGE
#TakeABiteAtHome AT HOME

Work-it-out worksheet references for facts

- Did you know ‘*Cows have a stomach with four separate compartments to digest their food*’ and did you know ‘*Cows regurgitate food after swallowing so that they can chew it again! Tiny organisms in cows’ stomachs cause them to burp a powerful greenhouse gas called methane (CH4)*.’
  This information and more regarding the process of digestion and rumination in cows can be found at https://www.fda.gov/media/80784/download

- Did you know ‘*Cows need to eat a lot of food to provide us with beef and milk! The cow uses this food to grow muscle and to keep warm, and some of the food comes out as poo!*’
  1) Per 100kg of dairy cow there is 80kg of poo (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcs143_014211)
  2) Average mass of a dairy Holstein cow is 700 kg. Using this, and that per 1000 kg of dairy cow there is 80 kg of poo, the average dairy Holstein cow will poo 55 kg a day (https://www.thecattlesite.com/breeds/dairy/22/Holstein/)
  3) The cow needs to eat about 3.5% of its mass in dry food. Assuming 700 kg mass, it will need around 25 kg of dry food a day. (http://dairy.ahdb.org.uk/resources-library/technical-information/feeding/#.Xse5sTpKjIV - section 7 ‘Managing your feeding’)
  4) The poo includes a lot of water. There’s about 12% dry matter in cow poo (https://www.canr.msu.edu/uploads/files/ManureCharacteristicsMWPS-18_1.pdf)
  So, our dairy cow takes in 25 kg dry food per day, and poos 55 kg a day. 12% of its poo contains dry matter. 12% of the 55 kg of a poo a day gives 7 kg ish. So of the 25 kg of dry food eaten 28% (‘some’) has come out as poo.

  ‘Cows use the nutrients provided to them for bodily processes in the following order: 1) maintenance – keep alive and moving, 2) lactation – providing milk for the calf, 3) growth – including weight gain, and 4) reproduction.’ (https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/400/400-012/400-012_pdf.pdf)

Work-it-out worksheet references for numbers

- ‘*For every gram of milk we drink, the cow causes 2 grams of emissions.*’
  For every gram of milk we drink, the milk production has caused 2 g of emissions, on average. This includes emissions from cow burps as well as methane and nitrous oxide from manure, and nitrous oxide and other emissions from growing food for the cow (and transport, packaging and refrigeration). Poore & Nemeck 2018, which can be downloaded with supplementary data https://josephpoore.com/ find a average value of 2.2 gCO2e / g milk for European dairy production, which we round to 2 gCO2e for the worksheet. Their global average is 3.2 gCO2e / g milk, which is higher than the European value mainly because their average value for Latin America and the Caribbean is 4.8 gCO2e / g.
  ‘*For every gram of milk we drink, the cow burps 0.5 grams of emissions.*’ A typical dairy cow produces 16 liters of milk a day and burps 0.26 kg of methane. (IPCC 2006, table 10.11 gives a milk rate of 6000 liters / year, which is 6000/365 = 16.4 liters / day, which we round to 16 liters /day.) The value of 0.26 kg of methane assumes dairy cows eat 70000 kCal / day and assumes 5% of the calories eaten by a cow are burped out as methane (Y_m in IPCC 2006; we use 5% as a rounded number - in practice it varies depending on the feed type e.g. is 3% for grains and soy). To convert this into the same scale as other greenhouse gases it is conventional to multiply by the 100 year global warming potential of methane, of 28, so this corresponds to 7.4 kg CO2e. 16 liters of milk weighs 16 kg, so for every gram of milk we drink the cow burps 7.4 kg CO2e / 16 kg * 1 g = 7.4 / 16 * 1 g CO2e = 0.46 gCO2e, which we round to 0.5 gCO2e for the worksheet.

- ‘*For every gram of beef we eat the cow causes 46 grams of emissions.*’
  Poore & Nemeck 2018 find an average value of 46.2 gCO2e / g of Bovine meat (Beef herd) for Europe, which we round to 46 gCO2e / g beef for the worksheet. Their global average is 99.5 gCO2e / g, which is brought higher than the European average mainly by their value of 179.4 gCO2e / g for Latin American and the Caribbean. Note that the BBC food climate calculator uses the world average value for beef https://www.bbc.co.uk/news/science-environment-46459714 . All these numbers include the impacts from farm to retail including cow burps, manure and deforestation for land clearance for agriculture (which is the main reason the Latin America and Caribbean value is so high).

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Work-it-out worksheet references for numbers

- ‘*14g of this 46g of emissions is in the burps*.’ A calf and it’s mother each eat about 40,000 kcal a day, so combined they eat 80,000 kCal a day (calculated from IPCC 2006 Volume 4 equation 10.16 https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html). We assume 5% of the calories eaten by a cow are burped as methane (the value ranges from 3% for high quality feed like soy to 6% for grass - using numbers from the above IPCC 2006 document). The emissions corresponding to this amount of methane weigh around 10kg (for details see Food and Climate Change -- Without the Hot Air, to be published by UIT Cambridge www.sarahbridle.net/faccwtha). So in total 10kg of emissions are burped by the cow each day. A cow will put on 700 g of edible weight (meat) a day (assuming a birth weight of 34 kg and that it lives for 1 year until it weighs 511 kg, and using standard factors for the fraction of edible weight). We can work out how much emissions there will be per kilogram of meat by dividing 10 kg gas by 700 g meat. This gives 14 kg CO2e/ kg meat (14 g CO2e/ g meat)
- ‘*For every 20 grams of food the cow eats, we eat 1 gram of beef*.’ A calf and it’s mother typically eat 40,000 kCal each every day (calculated from IPCC 2006 Volume 4 equation 10.16 https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html). The calf puts on 700 g of edible weight (meat) a day (see above). For each 100g of beef from a cow we get around 200 kCal worth of nutrition (you can look at a beef packet in the supermarket to find this out). For 700 g of beef we would get 1400 kCal worth of nutrition. If we divide the calories ‘grown’ by the cow which we will eat in a day, by the calories eaten by the cow and its mother in a day 1400/80000 = 0.0175 so we eat around 2% of the food eaten by the cow in the first place. So for every 50 grams of food the cow eats, we eat 1 gram of beef. The worksheet and activity video use a value of 20 instead of 50 by mistake (see Errata). The reason we consider both the calf’s food consumption and it’s mothers is because they both have to live for 1 year to produce a new cow.
- In the above calculation we assume that calories are proportional to grams of food and we ignore the detailed nutritional content of the food. In practice it depends on what the cow is eating. It is not clear this comparison is relevant if cows are eating food that humans can’t eat e.g. grass, especially if that grass is growing on land that is unsuitable for crops. However, on average we need 16 times less land to produce plant-based foods than animal-based foods (Poore & Nemeck 2018) so only a small fraction of the land needs to be suitable for crops to continue to feed the world. For more discussion of different ways of feeding cows see ‘Grazed and confused’ by the Food Climate Research Network https://www.fcrn.org.uk/fcrn-blogs/fcrn/new-report-released-fcrn-grazed-and-confused-fcct-commentary

Work-it-out worksheet Extra notes

Note on ‘emissions’:

In this worksheet we use the term ‘*grams of emissions*’ instead of ‘*grams of methane*’ because there is more than one gas that causes climate change. When we say ‘emissions’ we are referring to the combined effect of all these gases, including methane. Scientists often quote the warming effect of methane in terms of gCO2e (equivalent grams of carbon dioxide), because methane and carbon dioxide have different warming effects on the earth. Representing the methane emissions in terms of the equivalent amount of carbon dioxide can help us to compare the effects of the gases. The term ‘*grams of emissions*’ refers to the amount of carbon dioxide that would have the **same** warming effect on the earth as the emitted amount of methane, averaged over a 100 year period.

Note on calculating methane emissions:

Other approaches exist for comparing the effects of different greenhouse gases, see especially the approach pioneered by our Q&A panellist Michelle Cain (John Lynch, Michelle Cain, Raymond Pierrehumbert and Myles Allen Published 2 April 2020, https://doi.org/10.1088/1748-9326/ab6d7e). The usual approach averages the warming potential of methane over a 100 year period. However, we might be interested in the global warming effect on a timescale shorter than 100 years, especially since methane does not live as long as carbon dioxide. Methane causes much more warming than carbon dioxide when it is in the atmosphere. For example, the global warming potential averaged over a 20 year period is closer to 80 for methane (compared to the value of 28 used above for averaging over a 100 year period).

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Interview information

- LetUsGrow website: https://www.lettusgrow.com/
- Entocycle website: https://www.entocycle.com/
- India Langley interview: ‘Nitrous oxide has 300 times the heat-trapping power of carbon dioxide’ and ‘fertilizer is washed away or floats away as nitrous oxide or other gases’ https://www.nature.com/news/grass-gets-greener-1.13763
- India Langley interview: ‘Cover crops can take nitrogen from the air and bring it into the soil’ http://www.fao.org/3/CA2947EN/ca2947en.pdf
- Michelle Cain interview: ‘Methane is the 2nd most important warming gs after carbon dioxide’ (‘Methane has the second largest radiative forcing of the long-lives greenhouse gases after carbon dioxide’ https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf)

Additional resources

- The UK National Farmers Union (NFU) is a member organisation representing the interests of UK farmers. We are very grateful to Harriet Henrick (NFU Livestock Advisor) for joining us for the Q&A. Their Mythbuster document https://www.nfuonline.com/nfu-online/sectors/dairy/mythbuster-final/ presents information about UK red meat and milk, including citing a study by the UK Agriculture and Horticulture Development Board (AHDB) which states that UK beef causes 17 gCO2e per gram of beef, which is significantly lower than the value of 46 gCO2e / g we use in the worksheet, which is based on an average of many scientific papers for European beef (see above). We look forward to seeing the details behind the UK calculation so we can understand the difference.
- The NFU also provides range of educational resources to encourage more interest in where food comes from and help inspire and inform the next generation of farmers https://education.nfuonline.com/ Check out their upcoming Farmvention programme www.farmvention.com coming soon for 2020 with a title ‘Climate Change Superheroes'.
- EatFarmNow have produced #lockdownlearning tools working with farmers across the world https://eatfarmnow.com/category/lockdown-learning/
- Hear Harriet talk in detail for farmers about the practicalities of calculating greenhouse gas emissions for livestock on farms in this interview with Championing the Farmed Environment from 17 minutes in https://www.youtube.com/watch?v=US0cA-a7zvE including a discussion of Cool Farm Tool from the research group of our Theme 1 interviewee and Takeabitecc Team member Prof Pete Smith.
- Learn about land use and diets from the Greg (from the BBC’s Maddie and Greg show) https://www.youtube.com/watch?v=k7DQ0EEqxV4&feature=youtu.be

Errata/potential improvements

See page 2 ‘Work-it-out worksheet references for numbers’, we calculate that 2% of the calories eaten by a cow are available in the meat from that cow. This means 1 in 50 grams of food eaten by the cow make it through to the human. We incorrectly wrote 1 in 20 grams of food on the worksheet.

At one point in the showcase conversation we refer to a cow burping 46 grams of methane for each gram of beef, whereas the correct statement is that the cow causes 46 grams of emissions for each gram of beef (not all the emissions are methane, and we have used the standard conversion factor between the two, and not all the emissions caused by a cow are burped).

We welcome your questions and suggestions, to queries@takeabitecc.org