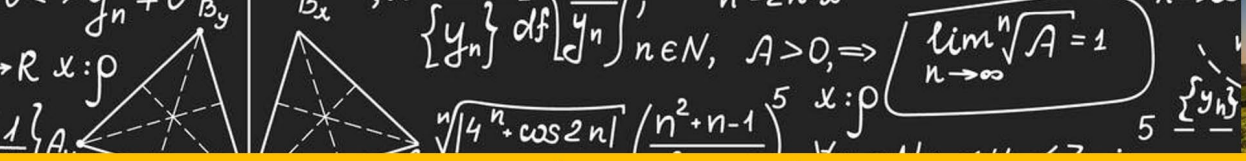


# Environmental Impact of Meat Consumption

## MATHEMATICAL MODELLING OF THE FOOD INDUSTRY: A USC designed course for National Science Week 2021

### OVERVIEW

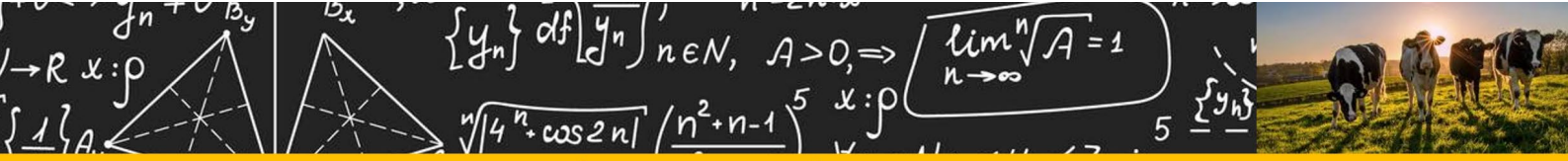
This activity has been designed to celebrate this year's National Science Week theme – "Food: Different by design". Over the course of 4 40minute long lessons students will be introduced to this year's theme, learn about the importance of maths modelling to solve real world problems and tackle a scenario around food consumption in Australia. With this step-by-step lesson plan and working in groups of 3 or 4, students will learn how to use their maths skills to determine the impact of Australia's annual meat consumption on the environment and how simple modifications to our diet can reduce the amount of $CO_2$ we produce from our love of meat. They will then be asked to present their models to the class. This could also be adapted depending on your school set up so that they present to the rest of the school or parents.

### Learning Outcomes

1. Develop mathematical skills for critical thinking and problem solving.
2. Learn about the environmental impact of our diets
3. Learn about this year's National Science Week
4. Learn about the importance of food sustainability
5. Learn about the importance of the food industry and how we need to change and adapt it to sustainably support future populations

### Equipment

Meat consumption lesson plan.ppt
2021_Student and Teacher Handout Meat Consumption.pdf
Meat consumption Worksheet.doc
Course Overview.doc
Practice Fermi Question.doc
Balloons for the first practice question



# Environmental Impact of Meat Consumption

## LESSON 1: Introduction to maths modelling and practice question

### Meat consumption lesson plan.ppt Slides 1-16

**Task 1 – 15mins: Introduce the theme of this year's National science week and run through the first part of session 1 (slides 1: 10) Maths modelling: what it is and and why it's important. These slides explain the importance of food and food security as well as maths models.**

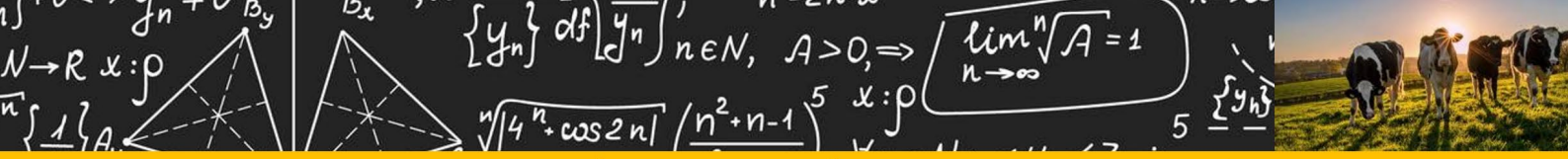
There are links to the National Science Week documents and websites on the slides so you can go into as much or as little detail as you like here. The important learning outcomes are 1. to understand that food sources are under strain around the world and that to feed our ever-growing population sustainable we will need to change our farming and eating habits. 2. To understand that we can use maths to model and solve very difficult global problems.

**Task 2 – 30mins: Run through the practice question (30mins) as a class. This is a fermi question that is designed to give the students practice at thinking laterally about big problems and using maths to solve them. It's a bit of fun and the actual answer is not that important, its about how the approach and tackle it.**

As a class work through slides 11-16. These slides present a fermi question that asks students to calculate/estimate simple volumes of the classroom and their own lung capacity to work out how many days' worth of oxygen we have in the maths classroom. The actual answer is not that important as this will vary depending on the people in the room and the room is not a sealed box. It is the approach that is important. This exercise aims to teach students how to think laterally to solve problems, that at first seem impossible to estimate. Use the **Practice Fermi Question.doc** and **balloons** here to estimate the students' individual lung capacity as the video embedded in slide 12 demonstrates

**Task 3 – 5mins: Wrap up and discuss results, how this information could be used to inform decisions about classroom ventilation etc. and how our approach could be improved in the future.**

There are many examples of fermi question that can be found online so the students may like to tackle others in their own time.



# Environmental Impact of Meat Consumption

## LESSON 2: Tackling the scenario part 1

### Meat consumption lesson plan.ppt Slides 17-25

#### The scenario we are presented with is:

Australia is one of the largest consumers of meat in the world. The average person in Australia now consumes ~100kg of meat a year. Animal agriculture is the second largest contributor to human-made greenhouse gas emissions after fossil fuels and is a leading cause of deforestation, water and air pollution and biodiversity loss. Raising and feeding livestock requires a lot of land. Land that could be used to feed a lot more people more efficiently.

Planetary health is a relatively new branch of science focusing on safeguarding the health of human civilisation and the state of the natural systems on which we depend. This branch of science has put lower meat consumption at the heart of reducing humanity's negative impact on the environment. Deforestation of land for livestock adds to the carbon footprint of a heavy meat diet and reduces available land that could produce far more plant-based food for the world's increasing population. In fact, in order to be able to sustain increasing population, we need to reduce our global meat consumption by half.

The Australian government is launching a public awareness campaign on the environmental impact of a high meat diet. The campaign will inform and encourage the public to move towards a more plant-based diet. The government has asked your group to provide valuable data on the environmental impact of Australia's meat consumption to help with the campaign.

There are many ways to approach this problem but a good place to start is to consider the amount of meat Australian's eat on average per year and the land required to raise that livestock.

#### Key points the Australian Government have asked you to address are:

1. How much land is used for animal agriculture globally and how much of that is used to sustain Australia's annual meat consumption?

2. If Australia led the way on this global mission to dramatically lower meat consumption, with every Australian reducing their weekly meat intake by 50%, how much land would be required to grow crops to provide the same amount of protein to replace meat in this more plant-based diet?

3. If this left over land was then reforested how much carbon would be absorbed from the atmosphere?

**Task 1 - 20mins: Read through the brief above as a class. Then take 5 minutes to discuss why excessive meat consumption is a problem for the environment and humans alike. Then put the students in groups of 3 or 4 and ask the students to generate their own problem statements (5mins) that they are going to work to – what is the problem that they think they have to answer? Get them to fill out the problem statement sections on their groups worksheet. Regroup and ask the students to share a couple of their individual problem statements (5mins). This is a chance to make sure everyone is up to speed and for students to modify their problem statement on their groups worksheet.**

The next 3 lessons are designed to be run with the **Teacher and Student handout.doc and worksheet.doc.** Now we are ready to move on to the modelling! To tackle this problem students will need to research global meat consumption, global landmass used for agriculture and Australian population to evaluate the land required to produce the amount of meat consumed annually in Australia. When modelling the potential to reduce landmass used, students will need to research land required to produce protein from different meat and plant-based sources. CO2 absorption rate of many different forests and other carbon sinks can also be found on the internet.

**Task 2 - 20mins: In their groups get students to break down the first point as we did with the fermi question and calculate values for global agricultural land use and Australia's meat consumption land use (15mins). Encourage them to use the links below and the internet to generate numbers to back up their educated guesses. Students should continue to fill in their group's worksheet with their values. Regroup and discuss their research findings together (5mins). Discuss their values and try and put them in perspective. 100,000km$^2$ is hard to imagine so put this in terms of country size for them (the UK for example is ~242,000km$^2$). The below work through is the way I would go about calculating the first point. From a quick search on the internet using the link provided I found the necessary values to work it out. There are many different ways to work these out and students may find different values whilst carrying out their own searches on the internet, but you can use the below to guide them if they get stuck.**

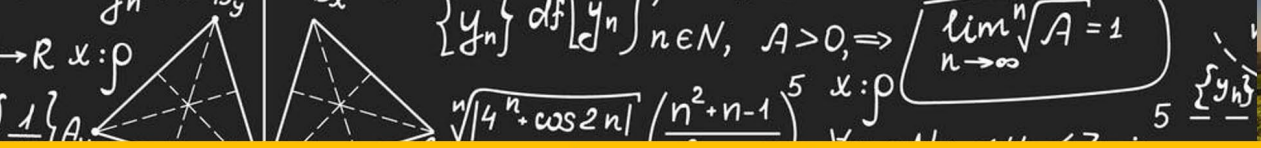
1. How much land is used for animal agriculture globally and how much of that is used to sustain Australia's annual meat consumption?

Land required to produce Australia's annual meat consumption

**Land used for animal agriculture globally** = ~26% of Earth's ice free land* = 33.8million km$^2$. This is about 4.4 times the size of Australia.

**Meat consumed globally per year** = 320 million tons.
Australia's meat consumption = ~100kg per capita per year** Population of Australia = 25.8million
Tons of meat consumed in Australia each year = 25.8 x 0.1tons = 2.6million tons
Percentage of total meat consumed by Australia = (2.6/320) x 100 = 0.8% of global consumption.

**Land used to provide Australia with meat***** = 33.8million km$^2$ x 0.008 = 270,400km$^2$. Roughly the land mass of New Zealand!



# Environmental Impact of Meat Consumption

## LESSON 3: Tackling the scenario part 2

### Meat consumption lesson plan.ppt Slides 26-31

**Task 3 - 25mins: Recap the 3 questions the government has asked us to answer (5mins) and get them to reread their problem statements. In their groups get the students to break down the second point and calculate the values for the land required to produce the same amount of protein from plants and compare to their meat values from yesterday (15mins). Encourage them to use the resource links and internet to research their problem. Regroup and discuss the research findings together (5mins). Answers may vary depending on the sources they have used but it's the process that's important.**

2. If Australia led the way on this global mission to dramatically lower meat consumption, with every Briton reducing their weekly meat intake by 50%, how much land would be required to grow crops to provide the same amount of protein to replace meat in this more plant-based diet?

Land required to grow crops to produce the same amount of protein

**Land required to produce 50% of meat** = 270,400km$^2$/2 = 135,200km$^2$

From a quick internet search I found (links provides in the resources)

100g of protein from meat requires 170m$^2$ of land.

and 100g of protein from soya, pulses and nuts requires 5m$^2$ (2.2-7.9m$^2$) of land.****

percentage of land that is used to produce meat required to produce protein from plants = (5m$^2$/170m$^2$)100 = 2.9%

**land needed to supply 50% of Australia's protein consumption from plants** = 135,200km$^2$ x 0.029 = 3,921km$^2$.

**Task 4 - 15mins: In their groups get students to calculate the carbon absorbed from the atmosphere if that excess land was reforested (10mins). Regroup and discuss results (5mins)**

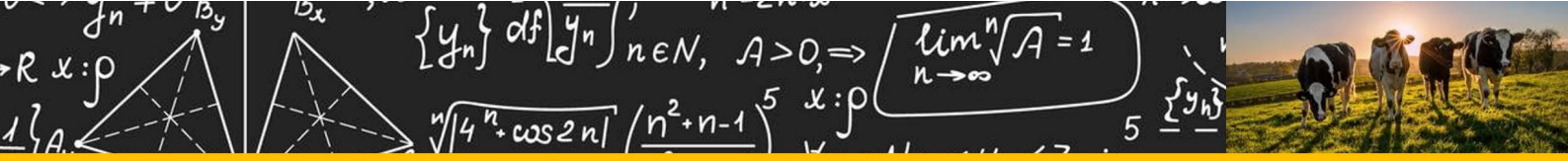
3. If this land was reforested how much carbon would be absorbed from the atmosphere?

Carbon absorbed from reforestation

**Land saved to be reforested** = 135,200km$^2$ – 3,921km$^2$ = 131,279km$^2$

From a quick internet search and using the links provided I found that 1km$^2$ of trees can absorb between 100 - 1,000 tons of $CO_2$ per year. Assume an average of 500 tons†

**Annual $CO_2$ absorbed** = 131,279km$^2$ x 500 tons $CO_2$/km$^2$ = 65.6 million tons $CO_2$



# Environmental Impact of Meat Consumption

## LESSON 4: Finishing off models and preparing presentations

### Meat consumption lesson plan.ppt Slides 32-35

**Task 5 – 20mins: Use this time to finish off models and/or expand them. Advanced students may want to think about the points below in the footnotes to extend their models.**

**Task 6 – 20mins: In their groups get the students to start preparing their presentations for another lesson that is convenient. Below is a loose brief that you can stick to.**

1. 1-2 slides in ppt no longer than 3mins long. All of you should present a bit of your model
2. start by stating your problem statement
3. explain how you answered your problem statement using your group worksheet as a guide
4. present your final results and what they mean.
5. explain any assumptions you made
6. give 1 example of an improvement you could have made to your model

**Footnotes - Points of Discussion and Exploration**

* This varies slightly depending the source and if land used to grow food for the livestock has been considered. Students may only model the land used to raise livestock, in which case this will be less.

** This can vary from 79-111kg per capita depending on year of survey.

*** There are several ways to estimate this and the answer may well be available online already.

**** Land required to produce protein from different sources can be found online. The example takes an average of land required to produce protein from beef, lamb and poultry as well as an average from land required to produce protein from soya, nuts and pulses. Students may wish to model a more accurate land size by researching % of beef/pork/poultry that is consumed annually.

† This varies depending on age and species of tree as well as climate. A temperate deciduous forest may store less CO2 annual than a rainforest for example. Students may wish to model different forest types that are typically found in the Australia or another carbon sink entirely. These absorption rates can be found online.

**USEFUL RESOURCES**

There are many ways to approach this problem and many sources for reference. Below is a list of useful links and hints that provide some background reading and may aid in your approach to the problem. These can all be access without special licenses to journals.

Environmental impact of eating meat

https://www.peta.org.au/issues/food/meat-envi- ronment/?gclid=CjwKCAjwwYP2BRBGEiwAkoBpAh-v16Lkuo1cr5YijJNYw8IgGyhQsxsdCVOZ7uV5Y-0IWQFHgEMgzj0RoCbfcQAvD_BwE

Land used for livestock globally

https://www.veganaustralia.org.au/impact_of_a_vegan_agricultural_system_on_land_use

https://www.globalagriculture.org/report-topics/ meat-and-animal-feed.html

Meat consumed globally per year

https://ourworldindata.org/meat-production

Land use per 100g of protein (this also quotes land used for agriculture globally as 40million $km^2$)

https://ourworldindata.org/agricultur-al-land-by-global-diets

Carbon absorption rate of trees (Some useful links as calculations vary greatly.)

https://www.thequint.com/tech-and-auto/how- many-trees-needed-to-absorb-co2-sadhguru-and- quint-calculations

http://medcraveonline.com/FREIJ/ FREIJ-02-00040. pdf

https://www.eea.europa.eu/articles/forests-health- and-climate-change/key-facts/trees-help-tackle-cli- mate-change

Carbon offset calculator

https://savingnature.com/offset-your-carbon-foot- print-carbon-calculator/?gclid=Cj0KCQjwnv71BRCOARIsAIkxW9HS2X-Q2dgRAPFkDATNsjAWiMehEcz8iwdHg-1du-R- b_3G-pWpe5ywaAsLtEALw_wcB