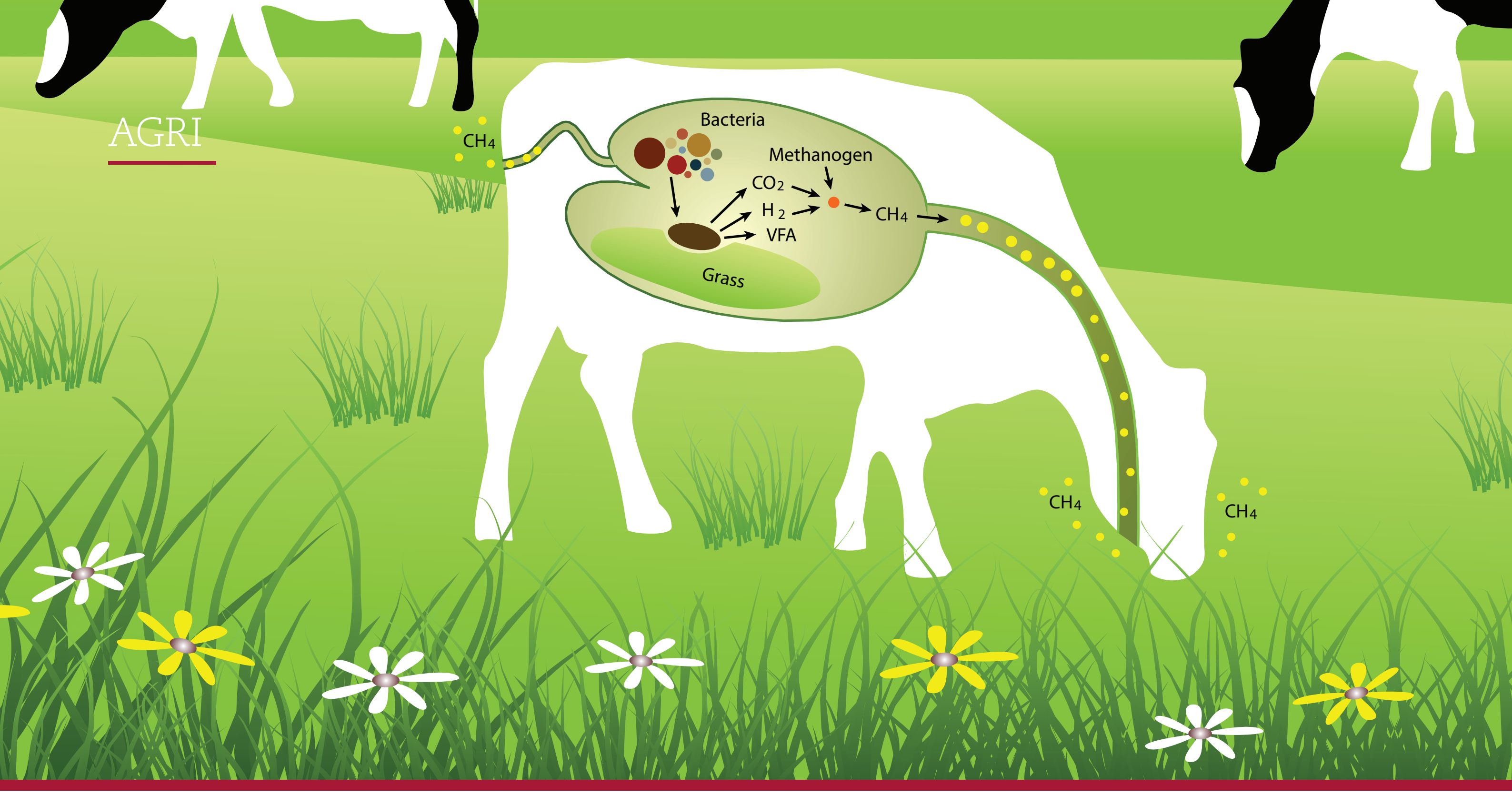

Rumen microbiome and methane emissions

TEAGASC researchers, along with colleagues in UCD and the ICBF, are participating in European-wide research into the rumen microbiome and its links to both productivity and GHG emissions.

Ruminant animals play a key role in global society, converting human indigestible plants into high-quality meat and dairy products for human consumption. Within the rumen dwells an ecosystem, known as the rumen microbiome, consisting of various microbes including bacteria, archaea, protozoa and fungi, all of which contribute different functions that allow the ruminant to obtain nutrition from plant matter. The rumen microbial community is highly differentiated and functions in an orchestrated manner, the outcomes of which are mainly beneficial to the overall nutritional status of the host animal.

One group of rumen microbes belonging to the kingdom archaea, known as methanogens, are, however, responsible for ruminant animals contributing ~40% of global agriculture's greenhouse gas (GHG) emissions through the production of methane. Methane as a greenhouse gas is 28 times more potent than carbon dioxide (CO_2), and is a major contributor to the quantity of GHG produced from agricultural-based activities. The production of methane, also known as methanogenesis, not only negatively impacts on the environment but is also an energy loss to the host animal, which ultimately directly impacts farm profitability. During the degradation of ingested feed particles in the rumen, hydrogen (H_2) is produced as a fermentation end product by some members of the rumen microbial community. The accumulation of an excess amount of H_2 hinders further rumen fermentation. Therefore, methanogenesis acts in a homeostatic capacity, resulting in the expulsion of excess H_2 from the rumen and promoting continued fermentation. While methanogens directly produce methane, various other bacteria, fungi and protozoa collude to produce a variety of fermentation end products, some of which act to supply the methanogens with substrate for methanogenesis, such as CO_2 and H_2. The methanogenesis process is energy inefficient, and has the capability to divert an estimated 6-12% of the animal's gross dietary energy intake away from productive aspects of the animal's performance, i.e., muscle growth or milk production.

Climate change crossroads

The need to supply nine billion people with high-quality animal-derived proteins by the year 2050 coincides with a somewhat conflicting requirement to mitigate climate change, and has therefore positioned global livestock production at a crossroads. However, an increasing body of research indicates that animals that are more efficient at utilising ingested feed for productive purposes also typically produce less methane and, in addition, have increased retention of dietary nitrogen. Increasing the nitrogen retention of ruminants is a very valuable concept, as excreted nitrogen is converted to nitrous oxide, a gas that has a global warming potential 265 times that of CO_2. Also, protein often forms one of the most expensive components of animal diets, so increasing the retention of nitrogen, a key constituent of protein, has potential to benefit farm profitability and ultimately meet human dietary protein requirements. In addition, previously conducted research from our own group and others has shown that the genetics of the host animal influence the composition and activity of its constituent rumen microbiome, with differences in the composition of the latter varying both between breeds and indeed between individual animals within a particular breed.

Cattle using the GreenFeed systems at the ICBF progeny test centre in Tully.

RumenPredict

RumenPredict, an international research consortium, aims to further advance our understanding of the association between the feed efficiency capacity of the host animal and GHG emissions, with particular focus on how the host shapes its constituent rumen microbiome.

As part of *RumenPredict*, over 400 beef cattle located at the Irish Cattle Breeding Federation (ICBF) cattle performance test facility in Tully, Co. Kildare, will be recruited to the study and undergo detailed study of: level of feed intake and efficiency; growth; GHG and nitrogen output; and, ultimately, meat yield and quality. To estimate the methane output, two GreenFeed systems have been installed at the ICBF progeny test centre in Tully. The GreenFeed system allows for the quantification of individual animal emissions within a normal production setting. To entice animals to use the machine, a small amount of bait feed is dropped when the animal approaches the unit, with all animals fitted with a unique radio frequency identification (RFID) tag for identification purposes. Contrary to popular belief, the majority of methane emissions are exhaled in the breath of ruminants and are not the product of flatulence. As such, while the animal consumes the feed, the air surrounding the animal's head, including that which is exhaled, is extracted via a fan, whereby it is passed by sensors and a subsequent value for each animal's methane emissions is determined.

In conjunction with this work, the composition of the rumen microbiome of each animal will be determined to identify differences between high- and low-emitting animals. Finally, in an effort to provide insight into linkages between the genetics of the host and its constituent rumen microbiome, a genome-wide association study (GWAS) will be conducted. Another aim of *RumenPredict* is to produce guidelines to encourage best practice for researchers investigating the rumen microbiome. These guidelines will include the development of a rumen-specific sequencing standard, containing known quantities of microbial DNA, and developing standardised laboratory procedures enabling across-country comparisons and amalgamation of data sets. At present, a rumen-specific microbiome sequencing standard is not available to assess the quality and accuracy of rumen microbiome DNA sequencing and analysis. Therefore, it is envisioned that the developed standard will be utilised as a quality control metric to assess the performance of future rumen microbiome sequencing projects.

It is envisaged that DNA-based biomarkers identified from this work will help to identify animals with a greater genetic propensity to efficiently utilise feed while minimising their impact on the environment. This will assist in meeting our aims of breeding animals that are both economically and environmentally sustainable to produce, and is wholly consistent with the goals of Food Wise 2025, the Government's roadmap for the future direction of the Irish agri-food industry.

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