

Web of relations

Mathematics and statistical methods can help discover the truths hidden in legends



The Battle of Clontarf by Hugh Frazer, 1826

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Celebration of the 1818 victory of the Mahar community fighting for the British against the Peshwa, Bajji Rao II, recently became a controversy in Pune, Maharashtra. While the community has traditionally seen the "victory tower" built by the British to commemorate the event as an affirmation of the lower castes, questions have been raised about the identity of the real contenders.

Another ongoing controversy is of how the 16th century Babari Masjid, at Ayodhya, came to be built. While the case for a Hindu temple to be constructed at the site of the demolished mosque is with the Supreme Court, the resolution of the matter may be more through diplomacy than on the basis of facts.

A similar, although less politically provocative, controversy is one regarding a victory of the Irish prince in 1014, which has been viewed as turning the tide against the Viking invaders. Joseph Yose, Ralph Kenna, Máirín MacCarron and Pádraig MacCarron of the Universities of Coventry, Sheffield and Oxford, write in the journal, *Royal Society Open Science*, that statistical analysis of the relationships described in historical sources has helped understand the political balance of the time with more clarity.

While a written, historical account is often the best source of facts that lie in the past, science and forensics have provided important supplementary information. Archaeology is an obvious example and chemical analysis or genetic profiling also has direct application. These sources become important when the written record is considered to be less than objective or misrepresenting the truth. In the case of Irish history, the

traditional understanding has been that the battle of Clontarf in 1014 marks the breaking of the two centuries old Viking power in Ireland. Some modern scholarship, however, looks at the conflict as a domestic feud or civil war, rather than an international clash.

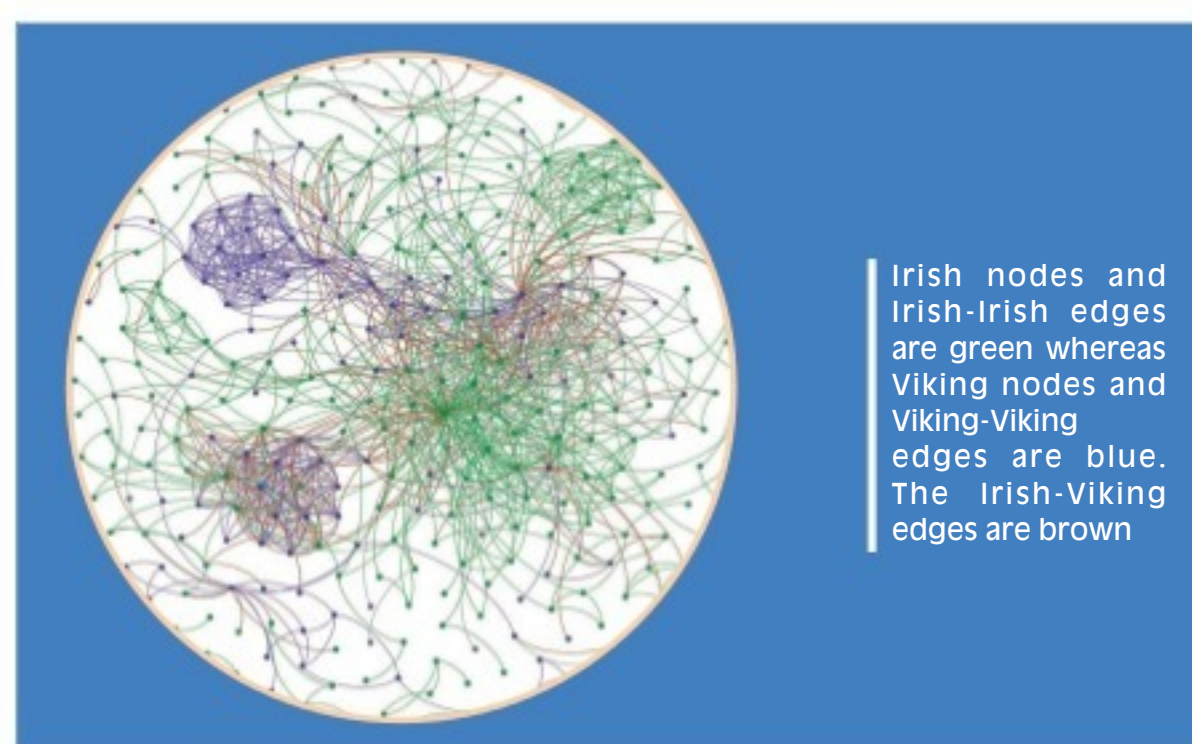
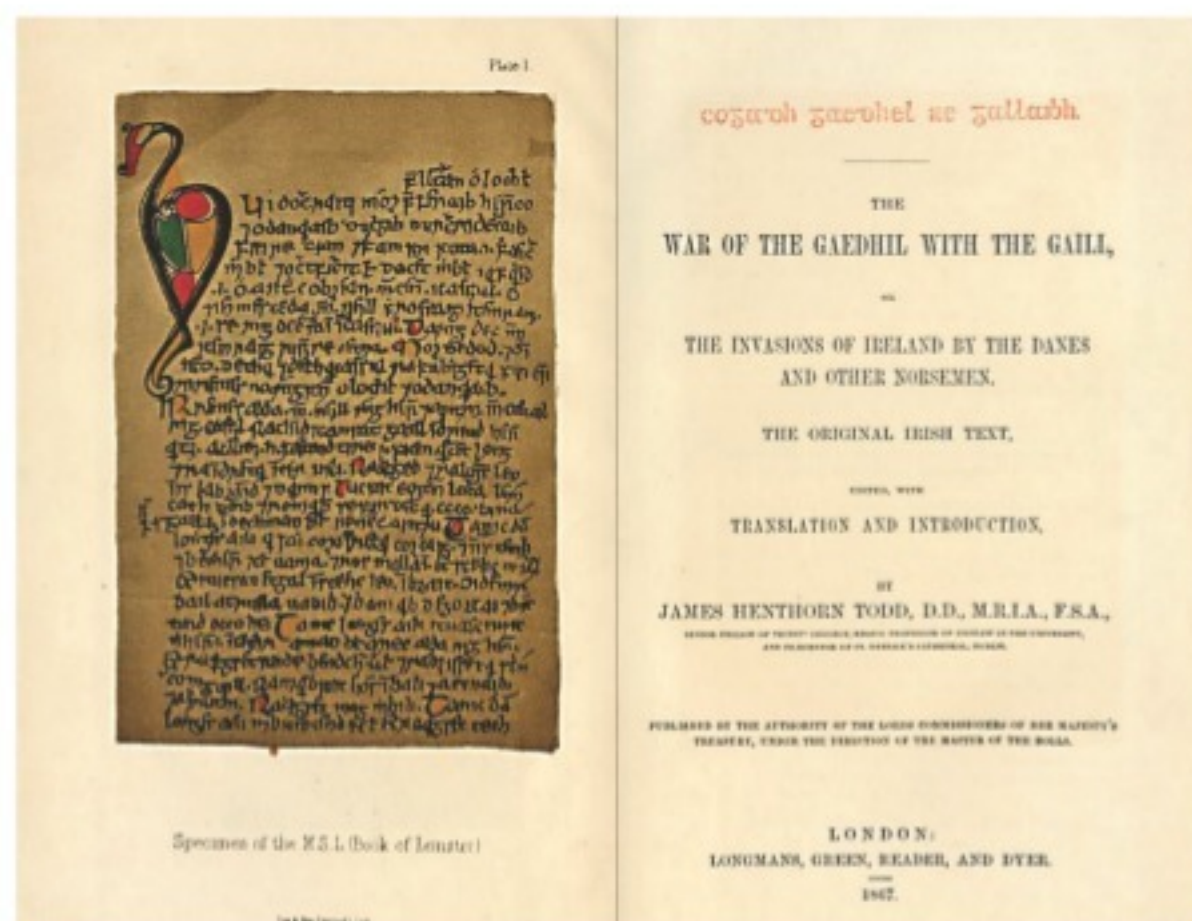
While controversy continues about how the records of a millennium ago should be interpreted, the paper in the *Royal Society journal* brings in mathematical analysis to present a perspective of the domestic and international issues considered in *Cogadh Gaedhel re Gallaibh* ("The War of the Gaedhil with the Gaill"), one of the best known accounts of Viking rule in Ireland. The narrative in the Gogadh, the paper says, describes the doings of the Vikings, who came to Ireland in 795 and grew in power till the iconic battle of 1014. The text describes "multitudes of characters, alliances, conflicts, relationships and interactions of all sorts", which have been used to model the interactions of the period in the form of a network of interdependent elements. The model can then be analysed using mathematics.

Mathematical methods bring objectivity and refine judgments in many fields, which are usually a part of the humanities. A ready example would be the use of mathematics in deciphering ancient writing, like the cuneiforms of Egypt or the Mohenjo Daro script. Another would be of creating a "fingerprint" of literary style, by statistical analysis of the use of words or sets of words in a writer's work. An imitation can then be made out even if it closely follows the style of the original to convince readers that a new work of their favourite author has been discovered. There are even features of numbers, themselves, that allow fake entries in bank accounts to

be identified! Relationships between groups of people, or institutions, have also been seen to form networks where the different entities connected to any one are also connected to each other and so on. These interconnections are similar to networks formed by roads connecting cities, airline routes, drainage systems, blood vessels in living things and the links between computers on the Internet. The networks have different structures, like hierarchical or organic, and the structures have different properties, which affect how fast connections between points can be or how easy alternate routes are if some routes get blocked or congested.

The mathematics of how networks function is now a subject of deep study. Methods to manage the capacity and geometry of routes for the fastest or cheapest way to transport goods, passengers or data have been developed. Analysis of networks has become important in understanding how infections spread and in controlling epidemics. Social networks are being seen as channels to spread information or for advertising. The entities that participate in networks are known in the field as "nodes" and the interconnections as "edges", which can be unidirectional or two-way, and the strength of the connection is called its "weight".

The mathematical analysis of the conflict in Ireland of the 11th century consists of discovering the links, or contacts between individuals and institutions in Ireland, appearing in the *Cogadh Gaedhel re Gallaibh* text, and classifying them as connecting nodes with similar attributes, like Irish, Viking or other, or nodes of different types. The edges, or the connection between the nodes, were then classified as representing familial or



Irish nodes and Irish-Irish edges are green whereas Viking nodes and Viking-Viking edges are blue. The Irish-Viking edges are brown

social relationships — a "positive" edge — or conflict or animosity — a "negative" edge.

The entire narrative yielded 315 significant characters, connected by 1190 edges. While there were groups of nodes with all positive edges, there were several triads, or groups of three, predominantly with two positive and one negative edge. A triad like this represents a pair of "friends" and a common "enemy" (a friend's enemy being mine too, or an enemy's enemy being a friend!). And their prevalence represents a suppression of conflict between pairs, thanks to their bonding against a common foe in the third, a case of "structural balance", the paper says.

One can see that while the participation of three kinds of nodes in positive and negative networks corresponds to the number of nodes there are, this is not the case with the kinds of edges that figure in the networks. Out of the Irish-Irish and the Viking-Viking edges, the bulk is in positive networks, representing social exchanges. But of Irish-Viking edges, there are more in negative networks, which represent hostility, compared to positive networks of the same.

"This suggests that the largest proportion of *Cogadh* conflict is international, but there are significant levels of intra-national hostilities too

(especially Irish versus Irish)", the paper says. The significant Irish-Irish hostility comes to light when we recognise that there is twice the number of Irish nodes as compared to Viking nodes in the network, the paper adds.

In fact, after considering the effects of the kinds of interactions possible, and the effect of "other" nodes, which are neither Irish nor Viking, the study concludes that the conflict in Ireland in 1014 was certainly more of the Irish-Viking kind, but was also Irish-Irish and Viking-Viking to a substantial degree.

The "traditional" view may have arisen from additions to the original narrative, along the way of editing and re-writing before the version that is available was created. The prose has even been described as "full of the feelings of clanship, and of the consequent partisanship of the time, disfigured also by considerable interpolations, and by a bombastic style in the worst taste..."

Mathematical analysis, based on more objective aspects of the record which would escape motivated distortion, however, has presented a picture that is more balanced and credible.

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PLUS POINTS

Microbial 'goo'



Scientists have developed a method of converting human waste into a potential food source that could be used by astronauts on missions to Mars and beyond. Using microbes to break down solid and liquid waste, they created the protein and fat-rich substance.

"We envisioned and tested the concept of simultaneously treating astronauts' waste with microbes while producing a biomass that is edible either directly or indirectly, depending on safety concerns," said Christopher House.

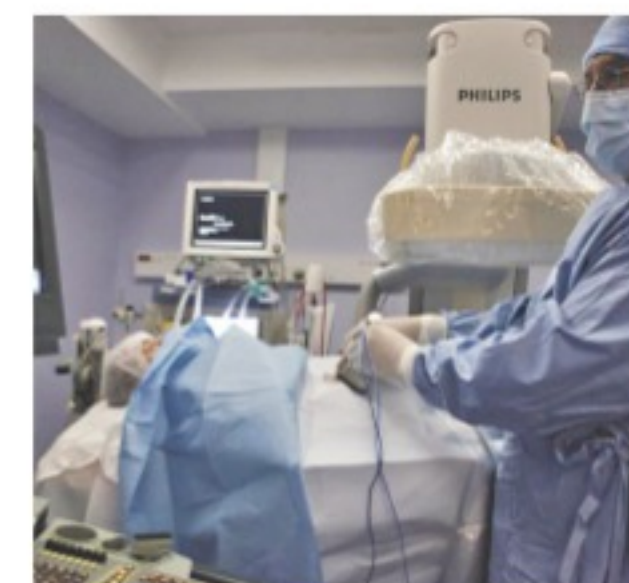
The microbe researcher at Pennsylvania State University added, "It's a little strange, but the concept would be a little bit like Marmite or Vegemite, where you're eating a smear of 'microbial goo'".

Food supply is a major hurdle when planning lengthy space flights. Growing food on board a spacecraft is energy and water intensive, whereas carrying food from Earth takes up room while increasing the craft's mass and therefore fuel costs. Recycling waste into nutritious food is one solution to this problem. Professor House and his colleagues outlined a method for producing a nutrient-rich substance from human waste using microbes, in their study published in the journal, *Life Sciences in Space Research*.

The method involves anaerobic digestion, a process that refers to the breakdown of materials in the absence of oxygen. It is considered an efficient way of breaking down biodegradable matter. The human waste anaerobic digestion process produced methane gas, which the scientists then used to grow another type of microbe called *Methylococcus capsulatus*. Besides efficiently producing a new food source, the new method is also able to break down waste quickly.

The Independent

Cancer imaging



In a major medical breakthrough, scientists of the Centre for Nanosciences and Molecular Medicine at the Amrita Institute of Medical Sciences, Kochi have succeeded in turning nanoparticles of calcium phosphate — a biomineral naturally found in human bones — into fully biodegradable radio frequency agents and made them imageable by MRI and CT scans. This has paved the way for safer, cheaper diagnosis and treatment of cancer. The project has been funded by the department of biotechnology, Government of India.

According to Dr Shanti Nair, director, Centre for Nanosciences and Molecular Medicine, Amrita Institute of Medical Sciences, "The development of calcium phosphate nanoparticles for drug delivery applications is a major innovation in the quest to develop biodegradable contrast agents for imaging (diagnostic) purposes. Calcium phosphate is naturally found in human bones and is non-toxic and fully biodegradable. Now that its nanoparticles have been made imageable by MRI and CT scans, their accumulation in tumours can be verified and the MR contrast used for image-guided surgical treatment of cancer."

Currently, the most common treatment for cancer involves radiation and use of gamma rays to kill the cells. However, this inflicts collateral damage — healthy cells also get destroyed along with cancer cells. Radiation treatment with Cyber-Knife is much more precise, but very expensive.

In this situation, the most easily accessible and cheapest cancer treatment available today uses radio frequency microwaves. But for this method to work, the RF agent should be non-toxic to the human body and preferentially accumulated in the tumour. This is where the development of calcium phosphate nanoparticles as a biodegradable RF agent becomes significant. A paper regarding this research was recently published in *Nature Scientific Report*.

The Independent

In grave peril

A new study suggests that plastic pollution is 'killing corals' by increasing risk of disease in reefs



A coral affected by the 'white syndrome'

JOSH GABBATISS

Plastic trapped in reefs around the world is having a serious impact on coral health, according to a new study. More than 11 billion pieces of plastic were lodged in the Asia-Pacific oceans corals, said researchers from New York's Cornell University who studied them. Such debris appeared to be leading to a greater prevalence of coral diseases, they wrote in their findings, published in the journal *Science*.

This contact with plastic increases the likelihood of disease striking corals from four per cent to 89 per cent. "Our work shows that plastic pollution is killing corals," said senior author Drew Harvell, an ecologist at Cornell. It is thought that the increase in disease could be due to plastic items blocking light and oxygen from reaching the corals, which require both to survive.

Depriving them of these could

also make corals more susceptible to infection by harmful microbes, known as pathogens. Plastic could also actively transport pathogens into coral reefs. "Plastic debris acts like a marine motor home for microbes," said Joleah Lamb, a marine biologist at Cornell University and lead author of the new study.

While the link with disease is unknown, past studies have established that plastics provide perfect havens for microbe colonies. "Plastic items — commonly made of polypropylene, such as bottle caps and toothbrushes — have been shown to become heavily inhabited by bacteria. This is associated with the globally devastating group of coral diseases known as white syndromes," said Lamb.

White syndrome is spread by bacteria, and causes parts of corals to die leaving a white band of dead tissue. "What's troubling about coral disease is that once the coral tissue loss

occurs, it's not coming back," said Lamb. "It's like getting gangrene on your foot and there is nothing you can do to stop it from affecting your whole body."

The new discovery comes at a time of increased awareness of plastic pollution. The UK Government has said it will make tackling plastic waste a top priority in its environmental policy. This year has already seen a UK ban on the manufacture of products containing tiny fragments of plastic called microbeads, as well as debate over the future of disposable coffee cups and plastic bottles.

By increasing coral's susceptibility to disease, plastic may contribute to the devastation of the world's reefs, many of which have already been weakened by a string of climate change-induced bleaching events.

To establish the link between plastic and disease, Lamb and her colleagues examined 159 coral reefs from Indonesia, Australia, Myanmar and Thailand. As well as documenting the plastic waste they saw, the scientists visually examined nearly 125,000 corals, looking for evidence of disease.

They found that when plastic was in contact with coral, the chance that it also showed signs of disease increased by a factor of more than 20 compared to coral that was plastic-free. "We know that plastics are widespread in the ocean, and it's no surprise to me that corals are encountering them," said Richard Thompson, a marine biologist at the University of Plymouth, who was not involved in the study.

Thompson added that in his own work he has documented over 700 species encountering plastic debris, and evidence of harm coming to them as a result. "Laboratory studies have shown that plastic encounters can cause really subtle, chronic effects and harm, compromising the ability of organisms to grow in the normal way for example," he said, "Any compromise like that is going to make creatures more susceptible to the risks of other diseases."

However, he noted that while plastic could present an extra challenge and may be linked with an increase in disease risk, this study does not show that plastics are carrying pathogens into the reefs. "They do



A spawning coral wrapped in a plastic bag

not present clear evidence as to whether the pathogens were transferred by the plastic — but that is certainly a possibility," he said.

Whatever the mechanism by which plastic is impacting coral health, the researchers want their work to inform efforts to protect the world's reefs. "Our goal is to focus less

on measuring things dying and more on finding solutions," said Harvell. "While we can't stop the huge impact of global warming on coral health in the short term, this new work should drive policy towards reducing plastic pollution."

The Independent

