Maths for all

Explaining concepts to the 'man in the street' is a worthy goal, but is not always feasible.

David Hilbert was extremely absent-minded, extraordinarily brilliant and the most influential mathematician of the twentieth century. His reach continues today. Among other things, he popularized a common concept in the communication of science: the 'man in the street', whose understanding (or not) of a problem is commonly used as a benchmark for intelligibility.

At the 1900 International Congress of Mathematicians in Paris, Hilbert set out to list the most important open problems of the field for the new century. But he also emphasized communication. "A mathematical theory is not to be considered complete," he said, "until you have made it so clear that you can explain it to the first man whom you meet on the street." Hilbert attributed the saying to "an old French mathematician".

That is unusually imprecise for a mathematician. So, to complete the theory, two intrepid maths historians set out to identify Hilbert's elderly Gallic source. As they report in this month's *Historia Mathematica*, they pursued a long paper trail, including a nineteenth-century letter published in *Nature*, and eventually succeeded (J. Barrow-Green and R. Siegmund-Schultze *Hist. Math.* **43,** 415–426; 2016).

It was indeed a Frenchman, one Joseph Diaz Gergonne (1771–1859), who first referred to the man in the street. In a letter dated 1825, Gergonne wrote that one has not said the last word on a theory until one has been able to explain it to a *passant dans la rue* — French for 'passer-by in the street'. A year later, in a second letter, he went further. A formula or method that could not be explained to a passing stranger "does not deserve to see the light of day".

That's a big ask, because the man (or woman) in the street sets the bar high. As most readers of *Nature* will know well, explaining your research to a non-expert is often challenging. Certainly, Hilbert acknowledged that the goal was an exaggeration. A more realistic one might be that attributed to Albert Einstein, who said (perhaps apocryphally) that things should be made as simple as possible, but no simpler.

That tension must have been on the mind of Nobel prize committee member Thors Hans Hansson in October. At a press conference, he was tasked with explaining the motivation for awarding this year's physics prize to David Thouless, Duncan Haldane and Michael Kosterlitz, who brought topology into physics in unexpected ways. In an attempt to illustrate the concepts involved, Hansson produced a bagel, a pretzel and a cinnamon bun from a bag.

"The man (or woman) in the street sets the bar high."

Topology is a relatively young branch of maths: when Hilbert made his list of open problems, he included few problems from topology. The field studies continuous deformations. The explanation goes that bagels and pretzels have different topologies because turning the former into the latter involves tearing the dough apart — not a continuous deformation.

There is no word yet from the street on whether Hansson was successful in his explanation. But Gergonne would surely have approved: he studied projective geometry, which involves shapes with exotic topologies, such as surfaces that have only one side. He would also, surely, be astonished that his 1825 passer-by continues to pass by the labs and lecture rooms of the twenty-first century, ever-ready to test his or her comprehension.

As for Einstein, Hilbert at one point raced him to the formulation of the general theory of relativity, only to later graciously concede. Hilbert is also credited with the dubious assertion that "Every boy in the streets of Göttingen understands more about four-dimensional geometry than Einstein", which seems to be taking the principle of the passer-by as arbiter a little too far. (In fairness, he then went on to admit: "Yet, in spite of that, Einstein did the work, and not the mathematicians.")

The new historical analysis solves one of the questions posed by Hilbert's famous speech, but plenty remain. The celebrated 23 Hilbert problems inspired researchers for decades; some remain unsolved. Luckily, the passer-by can wait. When a solution appears, he or she will surely be ready. ■

Home from home

We cannot look to the stars to solve our planet's problems.

World events this year have been thought-provoking. One thought present in many minds might be: how are the plans for a Moon base or a Mars colony coming along? So, some much needed good news! US engineers have published their design for a nuclear reactor that could power a permanent off-planet settlement for 15 years (K. J. Schillo *et al. Ann. Nucl. Energy* **96,** 307–312; 2016).

In 2009 (and how long ago that seems now), NASA identified such a reactor design as essential if astronauts were to visit and spend time on Mars. It runs (but these are mere details) on low-enriched uranium ceramic–metal fuel and uses supercritical carbon dioxide — cleverly extracted from the Martian atmosphere — as a coolant. With a reliable source of electricity, a Mars colony could then apply itself to what NASA calls in-situ resource utilization, and what everybody who saw the 2015 film *The Martian* will think of as growing potatoes in poo.

Don't pack your bags for this off-world utopia just yet. For what kind of society will such an isolated outpost create? A series of papers in the journal *Space Policy* speculate on human affairs on the red planet, and reach some depressingly familiar conclusions. The costs of getting to and living on the planet suggest the need for heavy corporate involvement, which could establish a conflict between those who want Mars to remain, well, Martian, and those who would develop and exploit its resources. Explorers must be able to plant a flag and claim territory (contrary to existing space law) to justify the trip — but, without restrictions, a free-for-all on the Mars landscape could ruin it for everyone.

The offered solution, naturally, is to divide Mars into exclusive economic zones, separated by a string of protected planetary parks. These would be safeguarded, naturally, by rules: no littering with spacecraft parts, and no walking or driving except on designated tracks.

Rules create a problem for colonists: whose interests do they serve, and who gets to decide them? A central Martian authority is a non-starter — attempts to impose a lunar government have stymied progress on a parallel Moon treaty — so some kind of tribunal system will be necessary, with appointments no doubt squabbled over by existing and new powers. Finally, there is the question of what happens should the colonists decide that they are sick of being told what to do by their parent planet. How should Earth respond to a Martian rebellion or conflict? Would we intervene? Would we take refugees?

One 'pragmatic' answer to all this likely division, researchers suggest, is the deliberate development of a new Mars religion, especially for those born on Mars. This could emphasize the sense and purpose of the mission, and help to justify the difficult living conditions.

The picture of Mars painted by these discussions, in other words, is a planet divided by politics, culture, religion, economics and inequality. Sound like anywhere you know? ■