Scientists have discovered slime mould — a single-cell organism at the bottom of the food chain — can learn.

Key points:

- Slime mould is a single-celled organism
- The mould learnt to cross a bridge that contained unpleasant substances to obtain food
- The findings could provide clues as to when and where in the tree of life learning evolved

The finding has important implications for understanding the evolution of intelligence, as well as how many organisms can be "smart" and successful without a brain.

Learning likely even predates the emergence of nervous systems, much less brains, according to a new study, which is published in the journal Proceedings of the Royal Society B. The research could explain why something as lowly as slime mould fares so well.

"Slime moulds are known for their surprisingly complex cognitive abilities: finding the shortest way through a maze, anticipating periodic events, choosing the best diet or avoiding traps," said lead author French biology student Mr Romain Boisseau of Toulouse University and Paris’ École Normale Supérieure.
Mr Boisseau and colleagues Dr David Vogel and Dr Audrey Dussutour investigated whether or not slime mould could learn to react in a beneficial manner to quinine and caffeine, two substances that it tends to avoid.

The researchers built a gel bridge that the slime mould, *Physarum polycephalum*, had to cross in order to obtain an oat-based snack on the other side. In one experiment, the bridge contained quinine; in the other, it contained caffeine.

**Learning by habituation**

During the first runs, the quinine and caffeine-containing bridges stopped the slime mould in its tracks. Eventually, after several hours, it slowly crossed the bridge and obtained the snack.

In subsequent runs, the slime moved ever faster over the bridge and toward the food. When quinine and caffeine were removed from the bridge, the slime went back to its original behaviour of crossing the bridge with no hesitation.

The learning exhibited by the slime mould during the experiments is known as habituation — where original behaviour changes in response to repeated stimulus.

This is different to simple sensory adaptation — where chemical receptors change their sensitivity due to a stimulus; or motor fatigue — where an organism is no longer able to respond because it is tired.

Mr Boisseau said basic learning required at least three steps: a behavioural response to whatever the trigger is, memory of that moment, and future changed behaviour based on the memory.

The organism must, however, "be able to recover from the process", such that it is not locked into the new behaviour, said the study's senior author Dr Dussutour.

The researchers are not yet certain how a single-celled organism like slime mould exhibits learning and cognition without a brain.

Prior papers authored by Professor Simona Ginsburg of the Open University of Israel and colleague Professor Eva Jablonka hypothesised that external modifications to DNA could potentially encode past experiences, allowing organisms without nervous systems to remember and learn.

**Other organisms without brains that 'learn'**

Plants also have the ability to learn, previous studies have shown.

For example, Associate Professor Monica Gagliano and Dr Michael Renton from the University of Western Australia and their team determined that the *Mimosa pudica* plant could learn to fold its leaves in a protective way in response to touch.
If the handling occurs gently over time, however, the plant stops wasting energy on adjusting the folding, having learned that this type of touch poses little if any threat. In another study, Dr Gagliano and Dr Renton found that plants could "talk" with each other via nanomechanical vibrations.

Dr Gagliano explained that "acoustic signals generated using nanochemical oscillations from inside the cell[s]" of plants could allow one plant to communicate with others that were nearby.

Other research has also demonstrated that single-celled organisms called ciliate protozoa may be able to learn.

Dr Dussutour, co-author of the current study, said bacteria may also be capable of learning.

"I think that learning is one of the best ways to adapt to the environment," Dr Dussutour explained.

"It's necessary for survival in most organisms, so I would predict that it would also exist in bacteria."

Dr Dussutour and her colleagues said simple forms of learning likely emerged before the evolution of specialised nervous systems. They pointed out that many of the processes that were considered to be fundamental features of the brain, such as integrating sensory information, decision-making, and learning, had all been displayed in various organisms without nervous systems.