Tiny Educators in Soil

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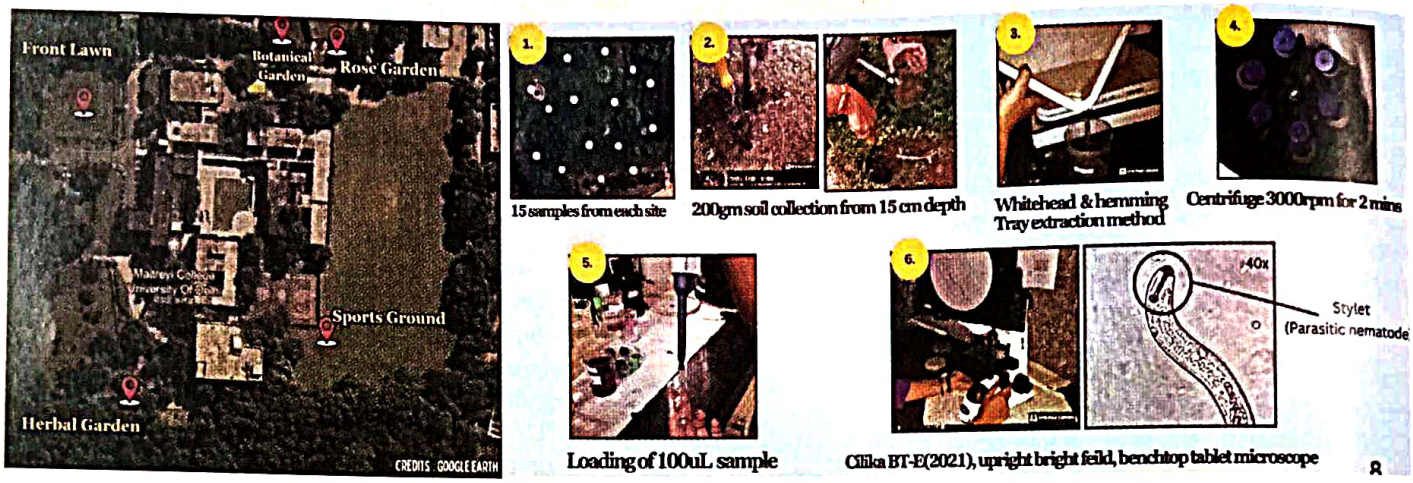

FROM the title, you might have guessed the organisms being discussed and wondered if these educators are soil bacteria. Here, we refer to another group of microscopic "educators" present in the soil — tiny nematodes (Greek: *"thread-like"*), which include both free-living and parasitic forms. They represent the most abundant metazoans and the unseen majority beneath the soil, and are a highly diverse group of organisms. They are commonly referred to as roundworms and inhabit a wide range of habitats, including deserts, oceans, grasslands, etc. The recently discovered (2025) nematode species *Crassolabium dhritiae*, named in honour of Dr Dhriti Banerjee, Director of the Zoological Survey of India (ZSI), highlights the rich yet understudied biodiversity of nematodes in certain regions. As EO Wilson famously stated, *"nematodes are so abundant that even if all other solid matter were removed, the Earth's structure could still be traced in these tiny worms — an illustration of their ecological omnipresence"*.

Nematodes have been aptly referred to as "nature's recyclers" or "tiny farmers" in science textbooks. They play a pivotal role in maintaining soil health and the ecosystem by regulating microbial populations with their diverse feeding habits. The soil nematode communities are also influenced by changes in the soil environment. For example, in a 2024 study by Li *et al.* from Gansu Agricultural University in China, the assessment of nematode diversity was studied in alfalfa fields in the semi-arid Loess Plateau. These regions are rich in alfalfa (*Medicago sativa* L.), which is a nitrogen-fixing legume. It was found that the number of plant parasitic nematodes increased with increasing levels of nitrogen fertilisers, thereby suggesting that long-term application of nitrogen supplements can significantly alter soil nematode communities. Such studies help us to understand that soil nematode communities are sensitive to changes in soil pH, moisture and ionic conditions, which in turn are affected by factors such as application of manures and fertilisers in soil. So, long-term usage of fertilisers rich in inorganic nutrients like nitrogen and phosphorus may lead to a substantial decline in the number of beneficial and free-living nematodes like bacterivores, fungivores, omnivores, and predators. Thus, understanding nematode diversity helps to understand soil ecosystems and provides a baseline for sustainable agricultural practices.

Nematodes have gained attention from their popular model organism, *Caenorhabditis elegans,* which has unravelled many important discoveries in the field of developmental biology molecular biology and biotechnology. In fact, *C. elegans* is credited with four Nobel prizes, including RNA interference, microRNAs, programmed cell death, and Green Fluorescent Protein (GFP) expression in *C. elegans*. These findings have provided critical insights into biological research and have contributed significantly to understanding the disease mechanisms of conditions like cancer and neurodegenerative diseases. In addition to their immense research potential, nematodes can also serve as efficient *pedagogy* tools for science students in senior high schools and undergraduate students. They help illustrate key concepts in developmental biology, cell biology, ecology, etc. Their rapid reproduction, transparent bodies, and easy tracking of behavioural responses make them convenient study models for researchers and students. Instead of merely drawing diagrams on paper, students can learn from these "tiny educators" by collecting soil samples and extracting nematodes in the laboratory. The extraction of nematodes from soil does not require any costly instruments; instead, they can be easily observed from a handful of soil with inexpensive equipment like plastic trays, flour sieves, a trowel and a compound microscope. Given the constraints of time and budget in educational settings, such simple experiments provide excellent opportunities for students to work with '*live*' animals. These opportunities become more important in light of the ban on animal dissections, especially for the Life science or Zoology students. So, inquiry-based assignments based on such laboratory exercises with complete hands-on training will greatly help in the teaching-learning process. Such assignments will fuel the scientific inquisitiveness of young