EXPLORE YOUR SURROUNDINGS WITH THE FOLDSCOPE

In middle school, we introduce children to the microscopic world — to organisms, cells, and structures that exist at such small scales that they are simply invisible to the naked eye. Microscopes play a vital role in this introduction. It is through microscopes that children begin to observe this world for themselves.

Many schools may have only one or a few microscopes that are bulky and expensive. Thus, much of a child's explorations of this tiny world is limited to classroom experiences that may be directed or facilitated by a teacher. Now, contrast this with a small, easy-to-use, and affordable microscope that children could carry around. What things would they observe? What questions would they ask? What would they learn?

The Foldscope

The Foldscope is a really simple, inexpensive, but powerful microscope. It was designed by Manu Prakash (a professor at Stanford University, USA) and Jim Cybulski (his PhD student at the time). Unlike conventional microscopes, the Foldscope:

- Is constructed with paper, magnets, and glass. This makes it small enough to fit into a pocket, sturdy enough for easy and rough use by school and college students, and handy enough to not need electricity or any additional resource. This makes it ideal for observations on the go.
- Is inexpensive, costing around Rs 350/piece in the Indian market.
- Has a magnification of 140x (which means that the size of the image we see is 140 times the actual size of the object we are looking at) and a resolution of 2 microns (which means that we can use it to discern features as small as 0.002 mm).
- Can be attached to a smartphone to take photos and videos of magnified objects, and can be used to project magnified images on a surface with just a bright light.

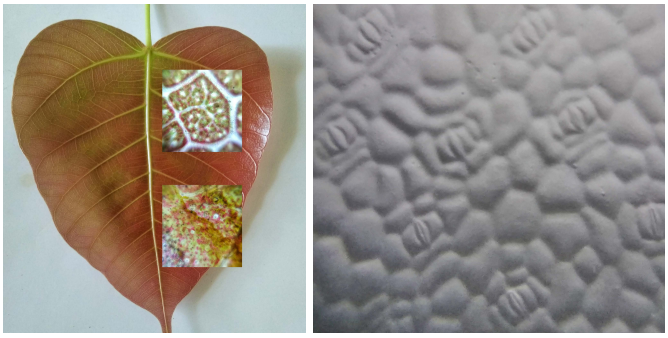
These features make the Foldscope particularly well-suited for exercises aimed at encouraging children to explore their immediate surroundings. For example, children could use it to observe changes in the colour and appearance of a leaf over time or monitor the opening and closing of its stomata — all without pulling the leaf off the tree. Preparing samples for observation of cross-sections also becomes much easier and faster. For example, a thin layer of nail paint can be applied to the back of a leaf. When this dries, it can be pulled off and observed under a Foldscope. Similarly, the sticky side of a piece of transparent tape can be used to touch the anther of any flower. This can be put on a paper slide and observed under a Foldscope (see **Fig. 1**). None of these preparations take more than a few minutes.

Uses in teaching and learning

Many students and teachers use the Foldscope to observe the natural world and document these observations as images. These images can be shared and discussed with many others on the online Foldscope community site. They can also provide data for experiments designed to answer a wide range of questions.

In one example, a high school student called Sameer (from Parbhani, a district in interior Maharashtra) who was documenting observations of pollen from various flowers in his neighbourhood, observed some powdery white spots on the leaves of a guava tree. This looked very much like pollen under a Foldscope. But based on his previous observations, Sameer knew that they were unlike the pollen of guava trees. This led him to ask — if these are pollen grains from a different plant, how did they reach these guava leaves? When he posted his observation on the Foldscope community site, some members suggested that Sameer observe a section of these leaves to check for infection. Some other members looked for and observed sections of

Fig. 1. Observations with a Foldscope.



(a) Leaf of a peepal tree *(Ficus religiosa)* with certain sections magnified.

(b) Stomata of a money plant (*Epipremnum aureum*).

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leaves with similar white spots under a Foldscope. They found thread-like structures that seemed to emerge from the deeper layers of the leaf. The pollen-like structures that Sameer had initially observed were at the outer ends of these threads. Discussions between Sameer and other Foldscope users led to the identification of the white spots as powdery mildew. In another example, MO Pandiarajan, a teacher from Tamil Nadu, and his students regularly use the Foldscope to explore jungles, ponds, rivers, etc. Pandiarajan also displays prints of microscopic photographs of everyday objects in exhibitions on roads, market places, bus stops, etc., where people can come and witness the beauty of nature at the microscopic level. In yet another example, students and teachers across India have been contributing images of pollen grains of plants native to their locations to a database on pollen on the Foldscope community site (see **Fig. 2**). Many of the photographs of pollen on Wikipedia have also been uploaded by Foldscope users.

Parting thoughts

My experience of working with children has taught me that their mind is full of questions about their immediate surroundings and the larger universe. Imagine a world where children can explore their microscopic worlds not only when they are in school, but anywhere and at any time. Access to sturdy, inexpensive, and easy-to-carry tools, like the Foldscope, can help children not only learn but also become producers of knowledge.

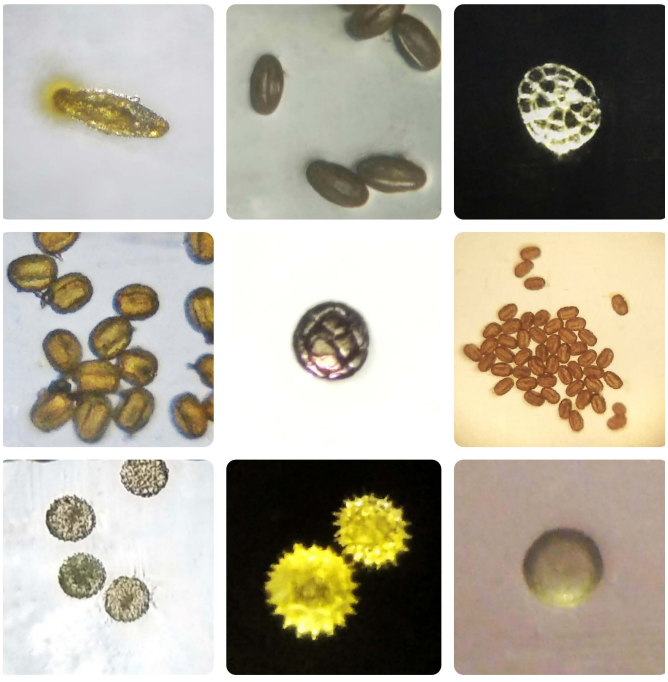

Fig. 2. Foldscope images of pollen grains of various plants.

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