

## Foldscope: Origami-Based Paper Microscope and Its Medical Applications

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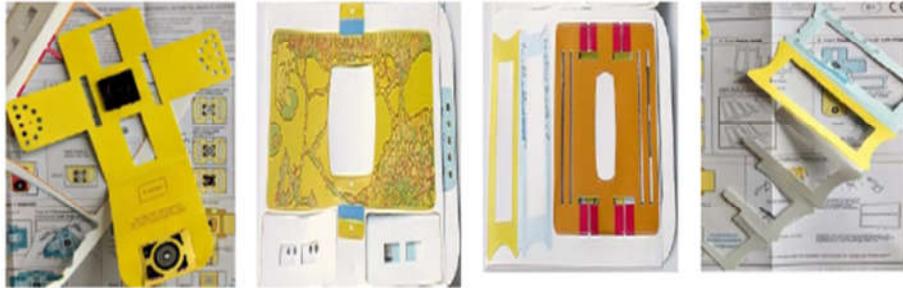
**Abstract:** Here we describe an ultra-low-cost origami-based approach for large-scale manufacturing of microscopes, specifically demonstrating brightfield, darkfield, and fluorescence microscopes. Merging principles of optical design with origami enables high-volume fabrication of microscopes from 2D media. Foldscope can be used in various disciplines like material science, physics, chemistry and life science such as biology and cell biology. In this paper, we present the applications of foldscope which can be used by everyone for various research as well as development purpose. We describe the experimental way by implementing foldscope on different applications which people can refer to learn how to use the Foldscope. We have displayed the results using a sophisticated camera in our case a mobile phone camera. People can similarly use imaging devices to show the effect and learn life at a microscopic level more precisely. Structural loops in folded paper provide kinematic constraints as a means for passive self-alignment. This light, rugged instrument can survive harsh field conditions while providing a diversity of imaging capabilities, thus serving wide-ranging applications for cost-effective, portable microscopes in science and education. We have used this foldscope in Food testing and nutrition, Sanitary care, Environment control and in the Agricultural field. We have also shown the use of foldscope in the educational field.

**Keywords:** Foldscope; Origami based Paper Microscope;

## 1 Introduction

Microscopes are universal instruments in science, giving an essential, visual association between the natural macro-world and the surprising first miniaturised scale world. Since the innovation of the magnifying lens, the field has developed to give various imaging modalities with goals moving toward 250 nm and littler. Cost-effective and versatile assembling is a vital piece of "frugal science and engineering". For instance, fabricating through collapsing has developed as a fantastic and broadly useful plan a technique with applications from nanoscale self-get together to huge gap space telescopes. All the more as of late, conceivable outcomes of collapsing efficient robots have been investigated with actuators, sensors and flexures incorporated in a consistent mould.

Foldscope is an origami-based paper microscope which can be assembled from a punched sheet of cardstock and lens[8]. The Foldscope is firstly printed on a card sheet and the according to the marking on the card sheet the Foldscope is assembled the same way as in origami craft works. The lens is also assembled in the foldscope [8]. It is used for the magnification required for getting a microscopic view of the subject or sample being tested by the foldscope user. There are also magnetic couplers used for connecting a sophisticated camera or another imaging device which is used for capturing images of videos of the sample. The magnification of the foldscope ranges from 140X to 2000X and 2micron resolution [8]. The cost of this foldscope is too low and the production costs as less as 1\$. It is a simple pocket-friendly microscope, and the size after proper assembly of the Foldscope is approximate 8.3x17.8 cm and weighs less than 10 grams [8]. For focusing the sample, there are two scales provided on the foldscope which can be moved to focus on a specific region of the sample. The time required for assembly of foldscope is less than 10 minutes that too without any professional help. This makes foldscope more user-friendly and travel-friendly microscopic device. The application of this foldscope is limitless, and it can be applied for research as well as testing purpose in various fields. As there is no limit for the range of magnification we can get magnification at a cellular level and even more profound. There are also led light source which can be mounted on the foldscope using magnetic couplers, and a small battery or any other light source can be used as an alternative to the led source. This light source is used for live projection of the sample being examined. This can be done in a low light environment as the bright environment can affect the intensity of the image being magnified [8].



**Figure 1. Four Stages Of Foldscope.**



**Figure 2. Foldscope.**

## **2. Applications of foldscope:**

Foldscope can be used for analysis as well as prevention of Human Life. Foldscope can be used to observe biological samples like bacteria, copepods, tardigrades, diatoms, rotifers, nematodes, spider eggs, mites, daphnia pretty much anything that you can stick on a slide. Foldscope have various uses in medicine, agriculture, education, sanitation. Etc.

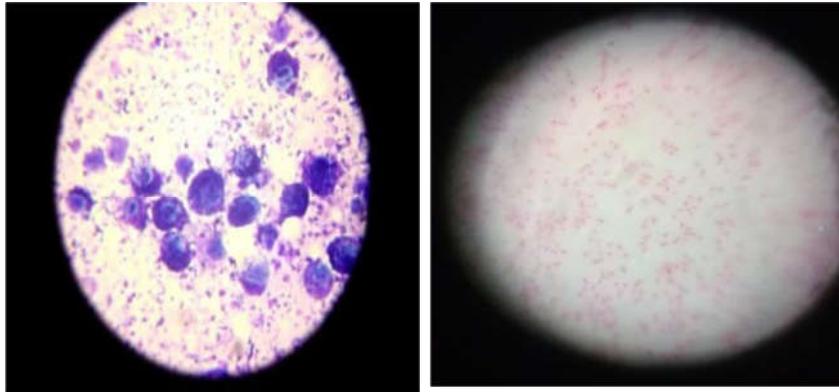
## 2.1 Foldscope in medicine:

In case of human health, during any abnormal behavior in human blood and nervous system can be detected by certain preliminary measures and by taking certain medical diagnosis and care they can be treated well and can eventually cure the abnormal behavior. Sometimes there is an urge to make the diagnosis at microscopic level and for this the blood samples or any of the testing medium (saliva, urine, etc) is send to the laboratories which use foldscope to examine and conduct tests on the specimen. The transportation time delay due to the remote location of the laboratories based away from small hospitals makes it tedious to carry the specimen to the laboratories or the patient has to visit the laboratory personally for the same.

Foldscope is thus a simple and effective alternative and it can easily be available at every hospital regardless of the specialization of the hospital. Foldscope requires only the specimen slide to be created which is too easy when we have the sample to be tested. This specimen slide is then mounted to the foldscope and can be seen on a microscopic level of up to 140X which is enough for the impartment of the calamities causing the disease. Foldscope can be used to perform microscopic tests and diagnosis on the specimen to check the improper and infection causing cell in the specimen. This instantly calculated result is then used to make antibiotics and prescribe the medication to the patient undergoing the treatment. The Foldscope can be used to check the cells causing cancer and can be a very important factor for detection and preliminary analysis of cancer causing cells.

The specimen of the cancer tumor is mounted in the Foldscope and is used to locate the actual cancer causing and affected area in the body [9]. The sample images of the cancerous substance when tested against a Foldscope are given below.

The foldscope can give a image of the blood smear too which can be used for various purpose in some rural areas where the laboratories and equipment like microscope is not available.



**Figure 3. Cancer Cell.**

**Figure 4. Blood Smear.**

## **2.2 Sanitation:**

### **2.2.1 Diagnosis of Vaginal Infections:**

Vaginal infection mainly causes due to the discharge due to menstrual cycles and another type of discharge if seen is due to the infection caused due to the unhealthy vagina. To make an accurate diagnosis of a vaginal infection, it is essential to understand the type of bacteria causing the infection leading to different symptoms.

The microscopic test using Foldscope of the samples is essential to determine the proper procedure to cure it. The samples that are required to place against the Foldscope are to be prepared using vaginal discharge. Collect vaginal discharge samples using two swabs, Prepare two slides, one with two drops of saline and one with two drops of 10% KOH. This slides first the one with saline is tested against the Foldscope, and the results are captured using a sophisticated camera for closer examination and confirmation of trichomonas, clue cells, WBCs and usual SECs. Later the KOH solution is placed against the Foldscope, and the slide is tested for the yeast present in it [9].

### **2.2.2 Diagnosis of Vaginal Infections:**

As with vaginal infections, it is important to remember that normal male

urethra does not exhibit any type of discharge except urination and ejaculation, and when one is observed, it usually is indicative of infection. Examination of male urethral discharge is generally performed to confirm or rule-out gonococcal infection. To prepare the slide carefully roll a specimen swab onto a small area of the slide to avoid disrupting cells. Position the specimen slide firmly in the slide holder of the Foldscope. The result is recorded by the sophisticated camera and the type of infection causing germs or cells are examined, and the images can be carefully used to decide the proper treatment.

Foldscope can be used to make research and study in the sanitation field by undertaking the same procedures for preparing the slide and examining it. The different infections causing bacteria's and cells can be studied using Foldscope [9].

### **2.3 Foldscope in Animal Care:**

Veterinary doctors can use Foldscope for animal health monitoring as well as for their research for the development and endorsement of animal life. For students underlying the study of animal welfare and animal care, they can use Foldscope for their practical experiments. For finding the species and locating the genre of that species the Foldscope can be used for the detection of the cell [9].

### **3. Conclusion:**

Foldscope is a convenient gadget which designed by James S. Cybulski and Manu Prakash to reduce the price barrier between individuals and the interest and excitement of scientific exploration. Foldscope is the very affordable, origami based paper microscope. It is designed to be extremely portable, durable, and to give optical quality similar to conventional research microscopes. This paper describes the different applications of foldscope in medicine, education, investigation, sanitation, agriculture and animal care. Foldscope use not limited to above areas it can be used in another fields also.

## Acknowledgement

The authors gratefully acknowledge the Department of Biotechnology, Government of India for providing a fund for this research and express sincere gratitude towards James Cybulski, James Clements and Manu Prakash for designing and providing Foldscope.

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