



सत्यमेव जयते

DEPARTMENT OF
BIOTECHNOLOGY
GOVERNMENT OF INDIA



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DEPARTMENT OF
SCIENCE AND TECHNOLOGY
GOVERNMENT OF INDIA

Foldscope Microscope

A Novel Tool from Frugal Science



2023

ICAR
NATIONAL INSTITUTE OF
BIOTIC STRESS
MANAGEMENT

Rendering solution to biotic stresses

ICAR-National Institute of Biotic Stress Management

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Founder Director and Vice Chancellor

FOREWORD

Foldscope is a part of the "frugal science" movement which aims to make cheap and easy tools available for scientific use in the developing world.

Foldscope microscopy research concept was conceptualized during 2018 at ICAR-NIBSM, Raipur and subsequently we have received the grant from DBT, Gol to study the *"Surveillance and minimizing the risk of zoonotic diseases among tribal farmers through Foldscope Microscopy"*. Under this initiative, our research team explored the knowledge level of tribal farmers on zoonotic diseases and tribal farmer's attitude towards the use of foldscope microscopy. As a field level application, foldscope identified as a novel tool to assess the frozen semen quality to reduce the infertility rate and it is a novel application of Frugal Science movement. Foldscope identified as a novel and user-friendly tool to identify the plant pathogenic fungal diseases at In-situ condition. Total 16 fungal diseases and their causal organisms were identified based on morphological structure of pathogen and host species. As a capacity building initiative, 42 Foldscope demonstration cum hands on training on diagnosis of plant pathogenic fungal diseases organized, 1470 participants were benefitted. In addition, 31 rural youth trained as village level trainer to demonstrate the Foldscope microscopy for crop disease diagnosis at village level. More than 290 foldscopic observations and its results has been published in the online platform called *MICROCOSMOS* (<https://microcosmos.foldscope.com/>) Foldscope Community as a part of global knowledge sharing and free access of foldscopic research findings among scientific community.

I compliment the Foldscope Project team for their sincere efforts in disseminating the frugal science-based foldscope applications to reach the unreached and explored the multi-dimensional utility of Foldscope in agricultural research.


(P. K. Ghosh)

Foldscope Project Partners



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Introduction

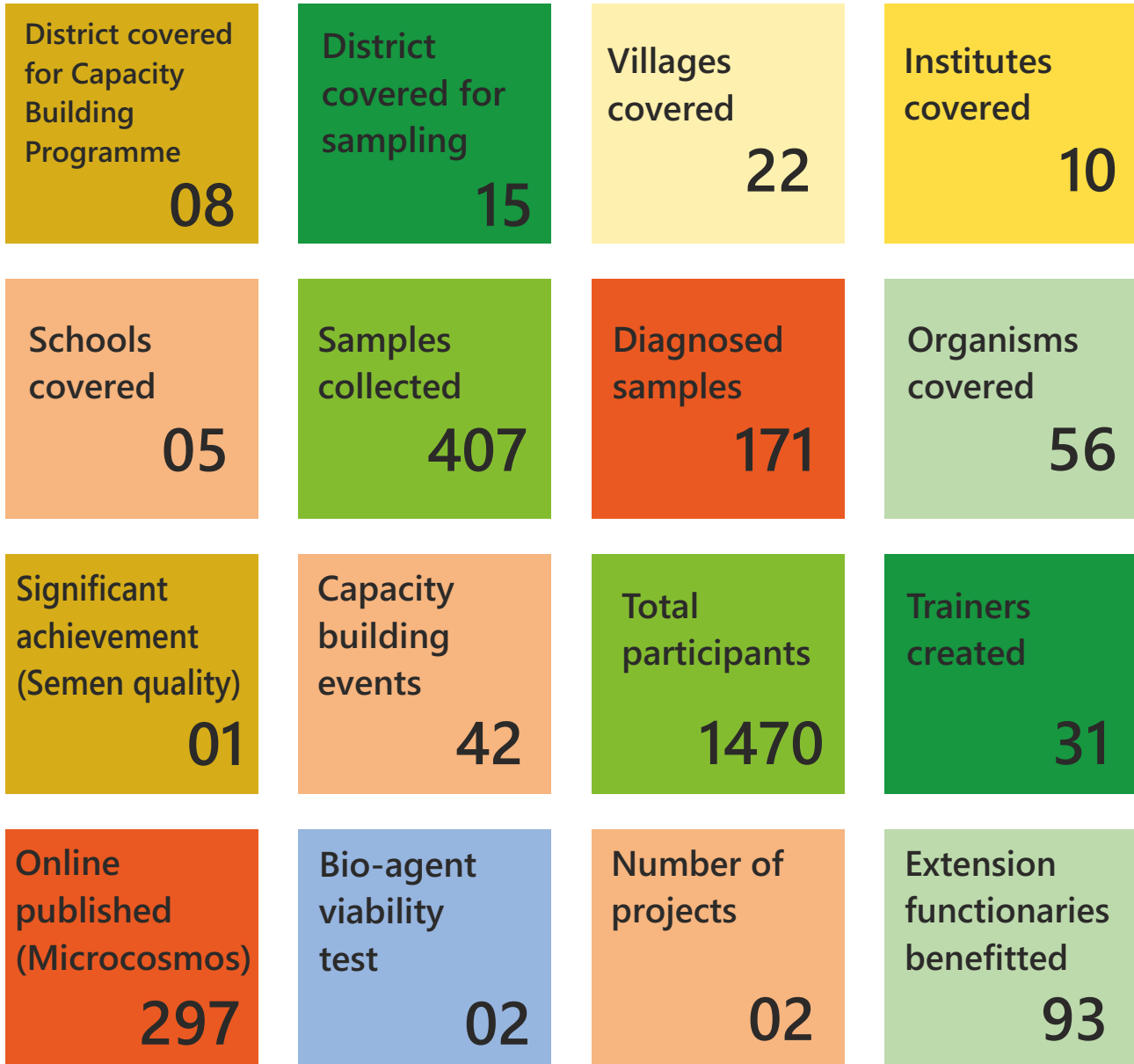
Foldscope microscopy research concept was conceptualized during 2018 at ICAR-NIBSM, Raipur and subsequently we have received the grant from DBT, GoI to study *the “Surveillance and minimizing the risk of zoonotic diseases among tribal farmers through Foldscope Microscopy”*. Under this initiative, our research team explored the knowledge level of tribal farmers on zoonotic diseases and tribal farmer's attitude towards the use of foldscope microscopy. As a field level application, foldscope identified as a novel tool to assess the frozen semen quality to reduce the infertility rate and it is a novel application of Frugal Science movement. In second phase, we have received the grant from Department of Science and Technology, GoI under SYST for three years (2020-23) to study the *In-situ diagnosis and digital cataloging of plant-pathogenic fungi through Foldscope Microscopy - A frugal science approach*. Under this initiative, foldscope identified as a novel and user-friendly tool to identify the plant pathogenic fungal diseases at In-situ condition.

Objectives of Foldscope Initiatives at ICAR-NIBSM

- ★ To develop digital catalogue of plant-pathogenic fungi from various diseased plant parts using Foldscope Microscopy.
- ★ To develop protocols for in-situ diagnosis of major plant-pathogenic fungi through Foldscope Microscopy at field level.
- ★ To educate and upscale the knowledge of rural youths and field-level extension workers on Foldscope microscopy for field-level diagnosis.
- ★ To minimize the risk of zoonotic diseases among tribal farmers through Foldscope microscopy.

Summary

Major Achievements (2018-22)



Area Covered



Chhattisgarh State

● Project implemented : 2018 / 2020

● Budget : Rs. 49.11 Lakh

★ Districts covered for capacity building

- ★ Raigarh
- ★ Janjgir-Champa
- ★ Balodabazar-Bhatapara
- ★ Raipur
- ★ Dhamtari
- ★ Durg
- ★ Rajnandgaon
- ★ Mohla-Manpur-Ambagarh Chowki

◆ Sampling districts

- ◆ Koriya
- ◆ Surguja
- ◆ Jashpur
- ◆ Raigarh
- ◆ Korba
- ◆ Sakti
- ◆ Mahasamund
- ◆ Balodabazar-Bhatapara
- ◆ Bilaspur
- ◆ Mungeli
- ◆ Kabirdham
- ◆ Bemetara
- ◆ Raipur
- ◆ Kanker
- ◆ Bastar

Facts and Application of Foldscope

What is Foldscope microscope?

- ❖ “Foldscope is an optical microscope that can be assembled from simple components, including a sheet of paper and a lens.
- ❖ Foldscope names indicate that it is a folding microscope and It's designed to be an extremely very low-cost, portable, durable, foldable paper microscope and to give optical quality similar to conventional research light microscopes
- ❖ It was developed by Dr. Manu Prakash, Associate professor, Stanford University, California, USA and designed to cost less than US\$1 to build.
- ❖ It is part of the “*frugal science*” movement which aims to make cheap and easy tools available for scientific use in the developing world.
- ❖ The Foldscope weighs 8 grams and comes in a kit with multiple lenses that provide magnification from 140X to 2,000X.
- ❖ The kit also includes magnets that can be stuck onto the Foldscope to attach it to a smartphone, allowing the user to take pictures/videos of the magnification.
- ❖ The magnification power is enough to enable the spotting of organisms such as major plant-pathogenic fungus, nematodes, algal pathogen, *Leishmania donovani*, and *Escherichia coli*, as well as malarial parasites”.



Front view



Rear view

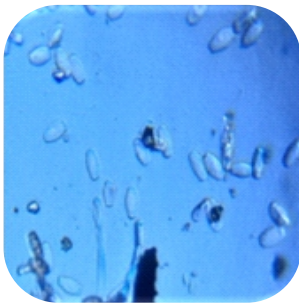
Why paper microscope is invented?

Microscopes are important tools for science, but they are often expensive to access and own. Foldscope's design uses low-cost materials (like paper) to provide a research-quality microscope for a fraction of the price so that everyone can explore the microscopic world.



What can be seen with Foldscope?

- ❖ Foldscope's lens has a magnification of 140x and 2-micron resolution. With that, we can see tiny things or samples like fungi, bacteria, algae and nematodes, etc.
- ❖ The larger things like insects, fabrics, pollens, and tissues can be also observed very easily under Foldscope.
- ❖ Foldscope can also allow the observation of non-biological samples, such as particulates detrimental to air quality or the microscopic crystalline differences between real and fake medications.
- ❖ As a field application, foldscope identified a novel tool for foliar plant pathogenic fungal diseases viz. powdery mildew, downy mildew, leaf blight, leaf spot, and post-harvest diseases, etc.



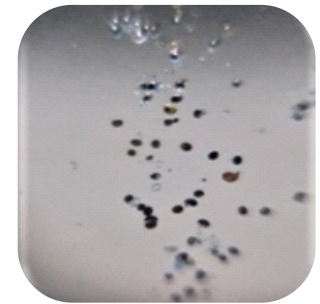
Fungus (*Golovinomyces*)



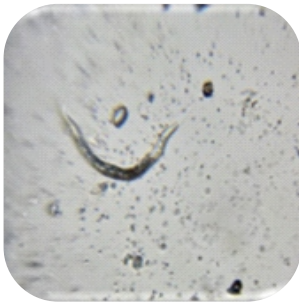
Bacteria (*Rhizobium*)



Insect (*Trichogramma*)



Algal (*Cephaleuros*)



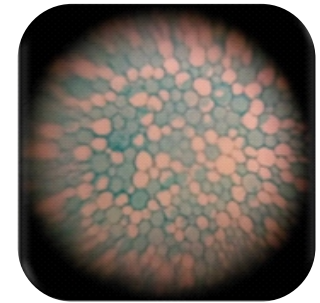
Nematode (*Meloidogyne*)



Histology - Uterus T.S.



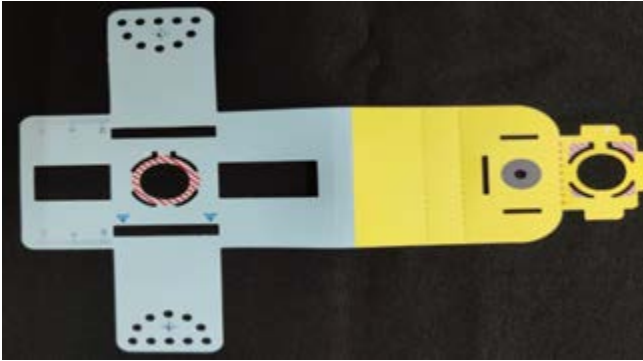
Histology stomach T.S.



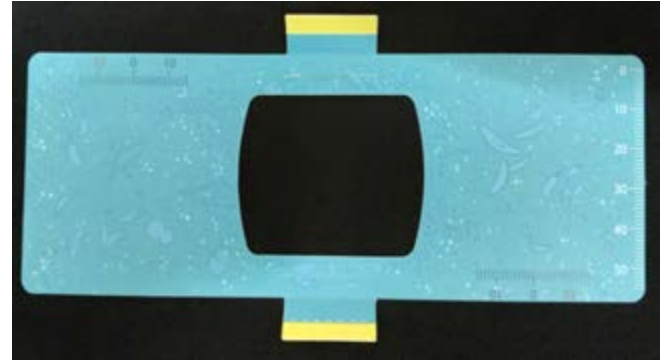
Dicot stem T.S.

Components of Foldscope

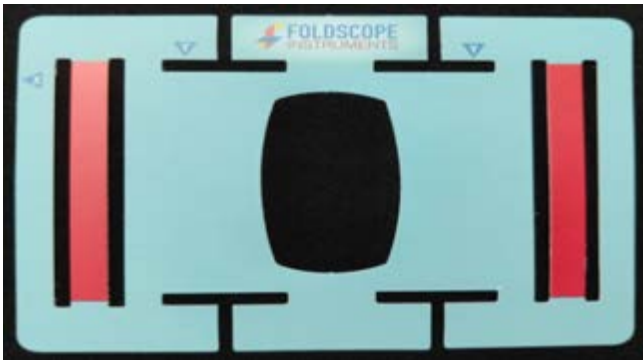
In fact, it is a conveyable type of microscope that is made from a series of paper clippings. Foldscope is made by very simple like paper seat, lens, and magnets. It can be mainly divided into four parts- lens stage, sample stage, penning guide and focus ramp. The lens is a glass ball that magnifies samples or specimens. The magnets align and place the lens and help devices attach to the Foldscope. The rest is of the Foldscope is paper.



Lens stage



Sample stage



Penning guide



Focus ramp

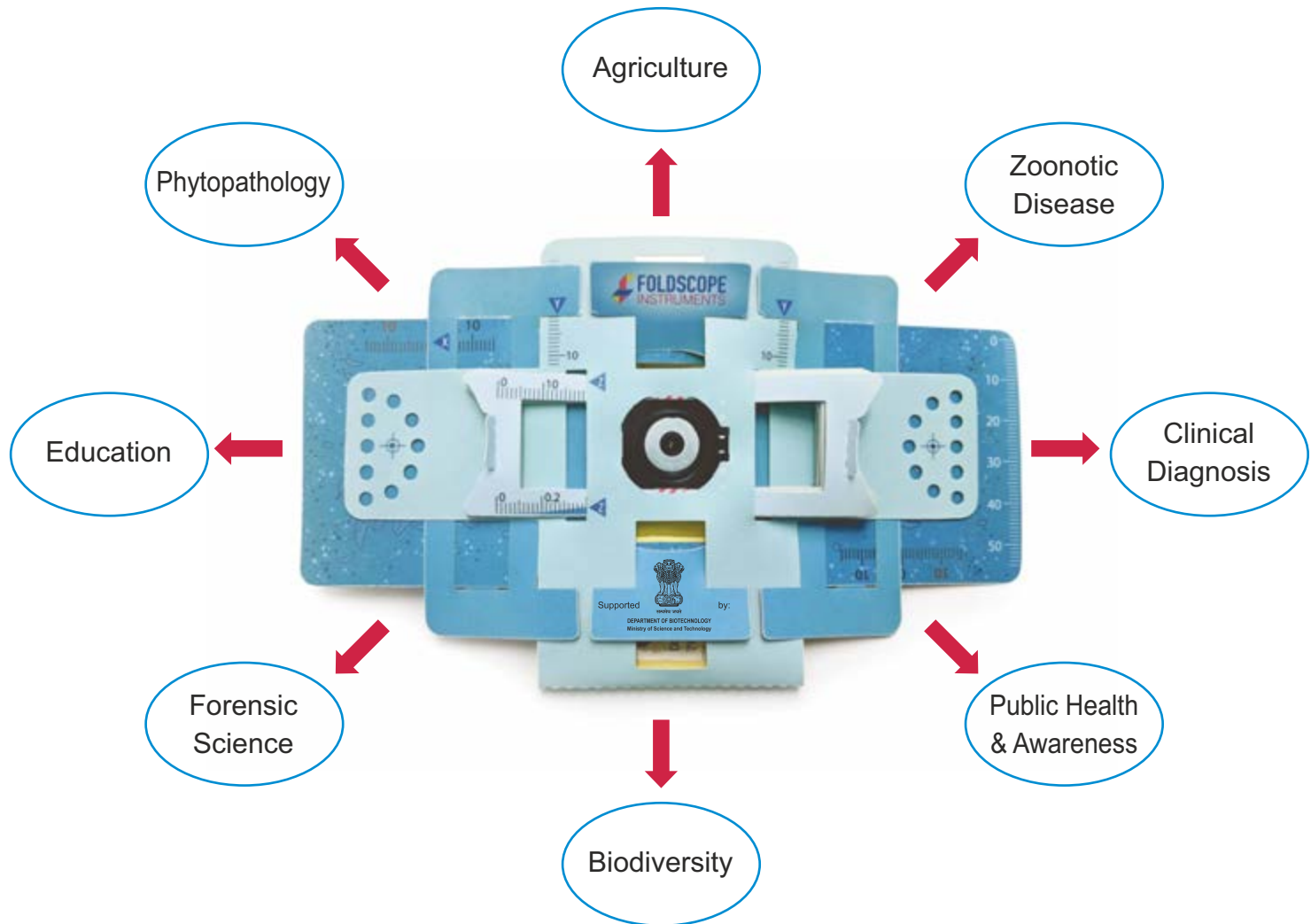
Key Metrics

Foldscope is a paper microscope with the following metrics:

- ❖ Magnification: 140x
- ❖ Resolution: 2 microns
- ❖ Back focal length: 0.56 mm
- ❖ Depth of field: 0.013 mm
- ❖ Field of view: 0.51 mm (diagonal radius)

Important area for Foldscope application:

The accuracy, speed, low cost, and effectiveness of the Foldscope microscope make better it to be easily used and studied in different sectors of agriculture, phytopathology, zoonotic disease, clinical diagnostics, public health and awareness, forensic science, biodiversity, and education.



Attachment of camera phone with Foldscope

The design philosophy of Foldscope is to bring the microscopic world to everyone. For this reason, Foldscope is designed to be an independent instrument and does not require a phone to use. Having said that, Foldscope works fantastically when coupled to phones or recording devices. No special app is required, only a standard camera application will be sufficient.



Projection is great for group viewing and sketching. Best results require a white flat surface in a dark room.

1. Place a double stick ring sticker* over the center of the phone's **flashlight**.

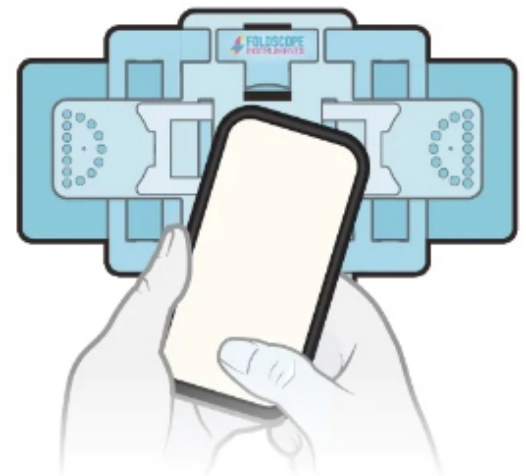
**Tape can also be used to attach coupler in place of ring sticker*



2. Place coupler (silver side UP) on top of sticker.



3. Mount the **blue side** of the Foldscope to the back of the phone.



Viewing method

Foldscope has three possible viewing methods like eye, phone, and projection. All of these methods are made to Foldscope very effective and smart.

(A) Eye viewing

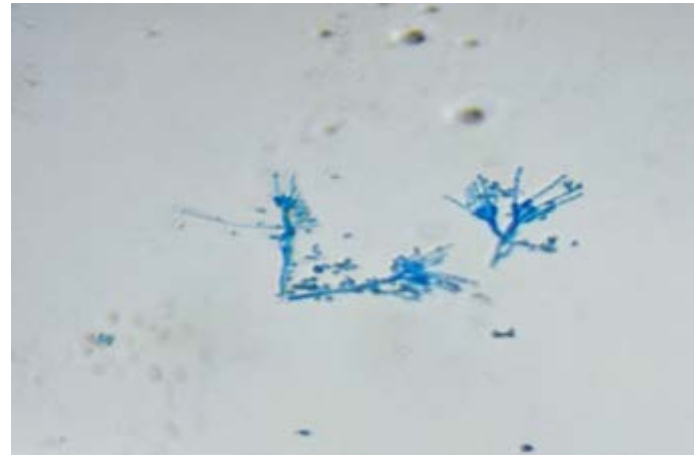
- ❖ To view any sample directly with your eye, first up make the temporary slides of the sample than hold the Foldscope with the blue side facing and bring the lens to the eye.
- ❖ While we view, point the back of the Foldscope toward a light source, such as a lamp or clear sky (*but do not look directly towards the sun*).
- ❖ Adjust the focus by nudging the focus ramp left or right with your thumb until the image appears clearly and pan to look at other areas of the sample by using your thumbs to shift around the lens stage.



(B) Phone viewing

We can use a phone camera as usual to record photos, videos and also zoom further into a sample.

- ❖ To view any sample with a phone, first off attach a coupler over the lens of mobile phone camera. (Make sure to place the coupler with the silver magnet side down, facing the phone.) The phone camera lens should be centered in the hole of the ring magnet. Attach the coupler to the phone by using a double-sided ring sticker or with any other tape.
- ❖ Once the coupler is attached bring phone's camera up to the Foldscope's lens. Phone should magnetically snap into place. If it does not, the coupler attached with phone is facing the wrong direction than once again try flipping the coupler over and reattach it.
- ❖ While viewing, point the back of the Foldscope toward a light source such as a lamp, LED magnifier or clear sky (*but do not look directly towards the sun*).



(C) Projection

Projection is another great method for group viewing and sketching. Best results require projecting onto a white flat surface area in a dark room.

- ❖ Projection requires a strong light source. A phone's flashlight works should be well. We can try using another flashlight using the same attachment method outlined here.
- ❖ Attach a coupler over the phone's flashlight. (Make sure to place the coupler with the silver magnet side UP.)
- ❖ Once the coupler is attached, bring the phone's flashlight up to the aperture on the back side of the Foldscope.
- ❖ Turn on the phone's flashlight and aim the front of the Foldscope at the smooth white surface. Now we should see an image of sample or specimen projected on the surface.
- ❖ From here we can pan and focus the sample as usual until this image is clear. To zoom in and move phone, Foldscope further away from the surface and watch the image expand. If it doesn't appear bright enough, try moving your phone and Foldscope closer to the surface.

Projection is great for group viewing and sketching. Best results require a white flat surface in a dark room.

1. Place a double stick ring sticker* over the center of the phone's **flashlight**.

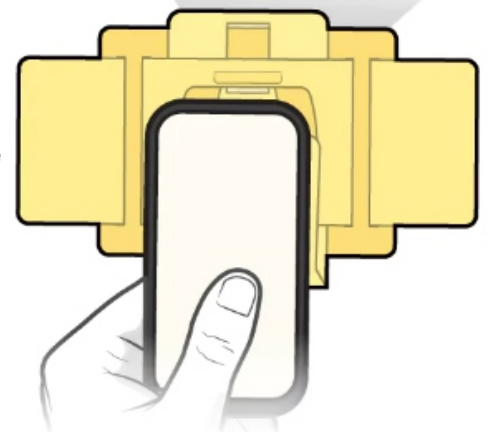
**Tape can also be used to attach coupler in place of ring sticker*



2. Place coupler (silver side UP) on top of sticker.



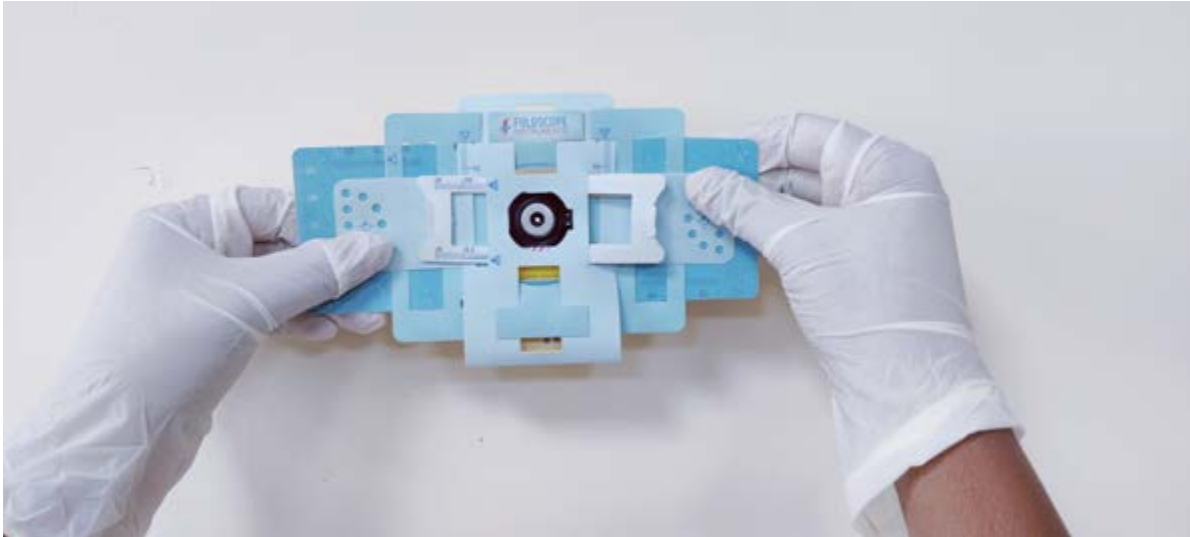
3. Mount the **yellow side** of the Foldscope to the back of the phone. Then project!



Moving and Focusing

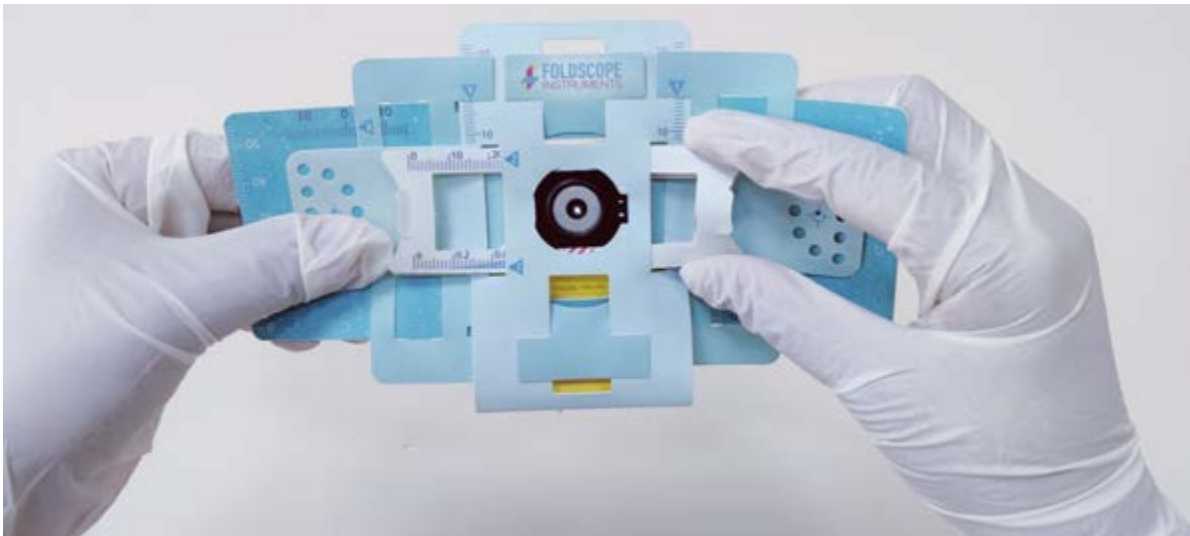
To move, press and move with the help of thumbs in the same direction.

- ❖ This motion will move the lens, allowing to explore different areas of the sample.
- ❖ See the objects in field of view move as with thumbs.



To focus, slide focus ramp either left/right or up/down with index finger.

- ❖ This motion will move the lens further/closer to sample, allowing to adjust focus.
- ❖ We should see the objects in field of view shift from blurry to crisp as slide the ramp.



Samples and Slides

Sample insertion

To use Foldscope microscope, just need to insert a sample so that there's something to see. It's easiest to view samples mounted on either a glass or paper slide. To insert a sample, flip your Foldscope to the yellow side and open the back flap.

- ❖ Hold your slide so that the sample is facing down, towards the lens.
- ❖ Hold the slide vertically in the middle of the Foldscope and insert each end of the slide into the top and bottom slots on the slide stage. The slide ends should be tucked under the folded flap.



Benefits of Foldscope:

- The foldscope is an ultra-low-cost microscope (less than a dollar) that can literally carry anywhere in pocket.
- It can be used in agriculture, to detect easily various types of microorganisms (fungi and nematode) which affect the crops and animals.
- It can also be employed in medical field like public healthcare centres for primary diagnosis or as personal health monitoring devices.

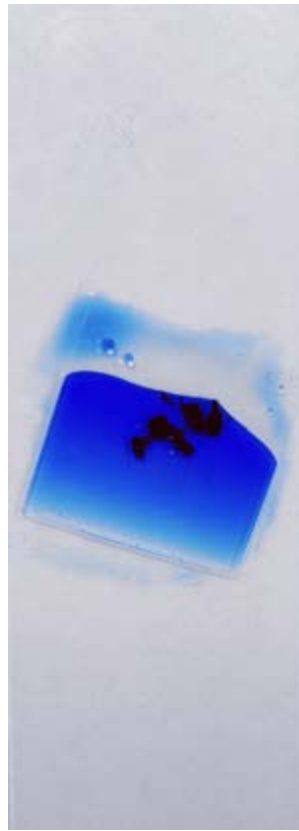
Light source

If we facing a light source and we won't be able to see anything if our sample or specimen isn't properly illuminated. To view a sample clearly, there must be light coming in through the aperture on the back flap. Make sure that we are facing something bright, such as the sky, a lamp, or a window. We can also use LED light instrument for more stable lighting.



Sample quality

If inserted a large sample that's over the lens and are facing a light source but still can't see anything clearly, our sample might be too thick. Try slicing it, squishing it, or spreading it out so that it is translucent enough to let light through or try using a brighter light source.



X



✓



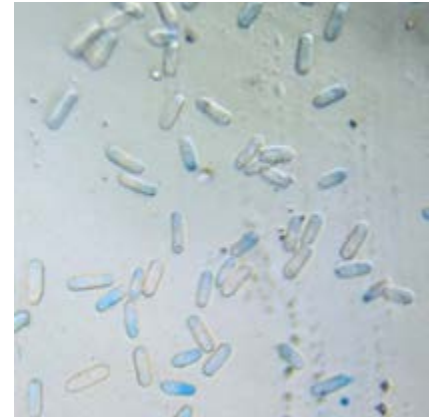
✓

Sample blurry

- **Focus:** Almost mostly time view a sample in a foldscope microscope, it will be blurry when first look at it. This is because need to bring it into focus by moving the sample closer to or further from the lens. With Foldscope, this is by sliding the focus ramp side to side. If the image is blurry, first try adjusting the focus and see if that makes it clear.



✗



✓

- **Sample towards the lens:** If we tried the full range of focus and image is still blurry than make sure slide is inserted so that the sample is as close as possible to the lens. In glass slides, this means that the side with the coverslip should be facing the lens, and the smooth glass side should be facing out. In paper slides, using only one piece of plastic tape, the sticky side with your sample should be facing the lens and the smooth tape side should be facing out.



✗



✓

- **Lens:** Make sure that lens should be clean and properly attached. Before viewing the sample, first should be clean to lens by rubbing each side of the glass ball for 10 to 15 seconds with the help of pointed cotton swab. Try to avoid touching the glass surface of the lens with your fingertips because our skin has oil that will smudge it. Check that we did not accidentally stack two lenses or attach an extra coupler this will make it very problematic and impossible to focus.



- **Lighting:** A good light source can make a huge difference in the quality of sample or specimen image. Make sure that you are pointing your Foldscope towards a bright, evenly illuminated area, such as the sky, a well-lit wall, or a window. If image seems unclear, try shifting angle towards the light or use a different light source. Although any bright light source works, the most stable and reliable way to illuminate Foldscope sample is to use LED magnifier light source.

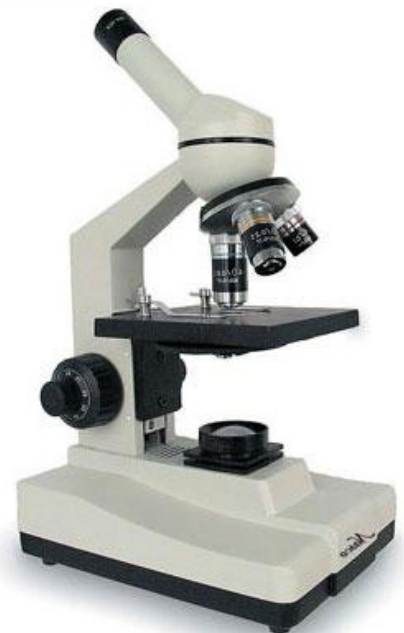


Comparison of Foldscope and Conventional Microscope

- ❖ Conventional microscopes typically have better optical performance, greater stability and control. Conventional microscopes are also often very expensive, less durable and big sizes.
- ❖ Foldscope is smaller, lighter, less expensive and more durable. This portability makes it ideal for field research, hiking trips, in situ disease diagnosis and other rugged scenarios.
- ❖ It is also ideal for under-resourced settings where people would not otherwise have access to a microscope.
- ❖ Although the low price is also an appeal for classroom use, Foldscope's main benefit is that it allows every student to have their own microscope, providing more hands-on microscopy time and opening new possibilities for independent research projects as students can take the Foldscopes home with them.
- ❖ Foldscope is not trying to replace conventional light microscopes. We still believe that it is important for students to learn traditional lab microscopy techniques when possible.



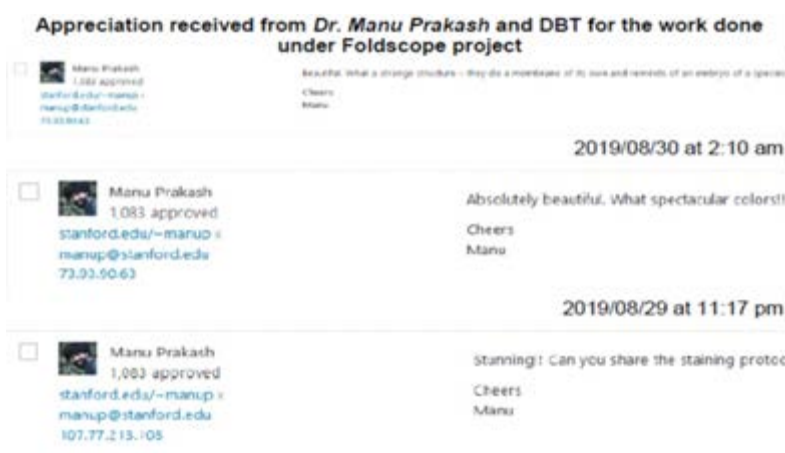
Foldscope microscope



Light microscope

Foldscope Community

The best part of Foldscope is not in the tool itself, but the people that use it. The Microcosmos is the collective term used for the Foldscope community & it provides an online platform for better connectivity among people community.



Diagnosis through Foldscope microscope



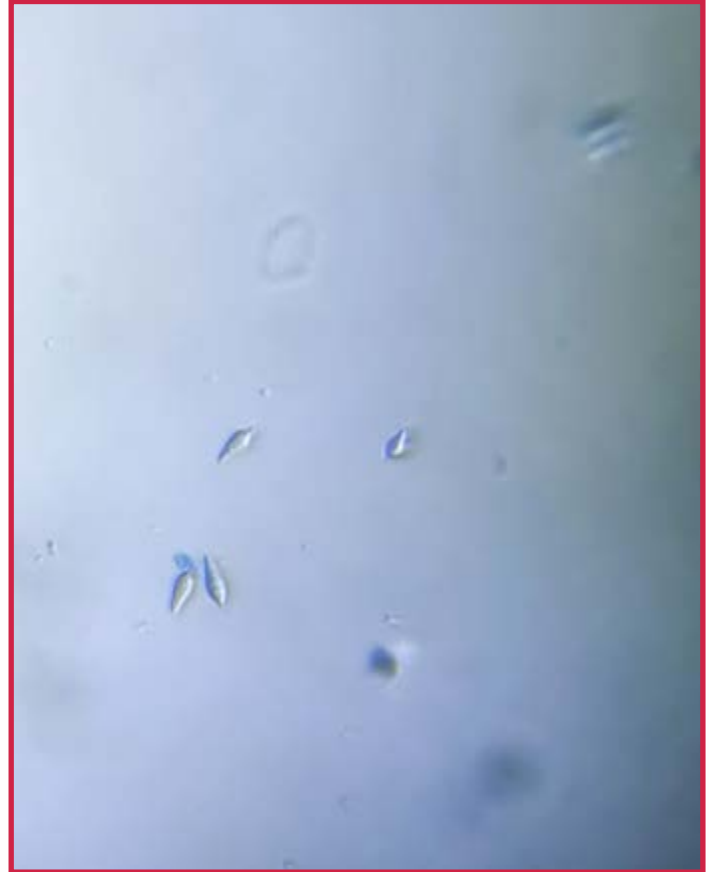
In situ diagnosis

(A) Disease of Cereal Crops

S. No.	Name of Disease	Identified Pathogen (Organism)
1	Blast disease of rice	<i>Magnaporthe grisea</i>
2	False smut disease of rice	<i>Ustilaginoidea virens</i>
3	Brown spot disease of rice	<i>Helminthosporium spp</i>
4	Brown rust disease of wheat	<i>Puccinia spp</i>
5	Loose smut disease of wheat	<i>Ustilago tritici</i>
6	Blast disease of finger millet	<i>Magnaporthe grisea</i>
7	Wheat seed (Seed pathogen)	<i>Curvularia spp</i>
8	Wheat seed (Seed pathogen)	<i>Helminthosporium spp</i>

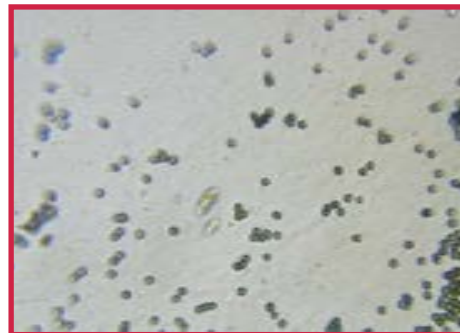
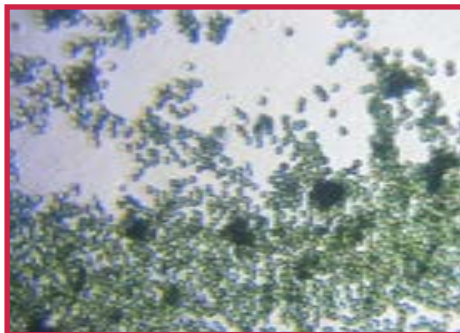
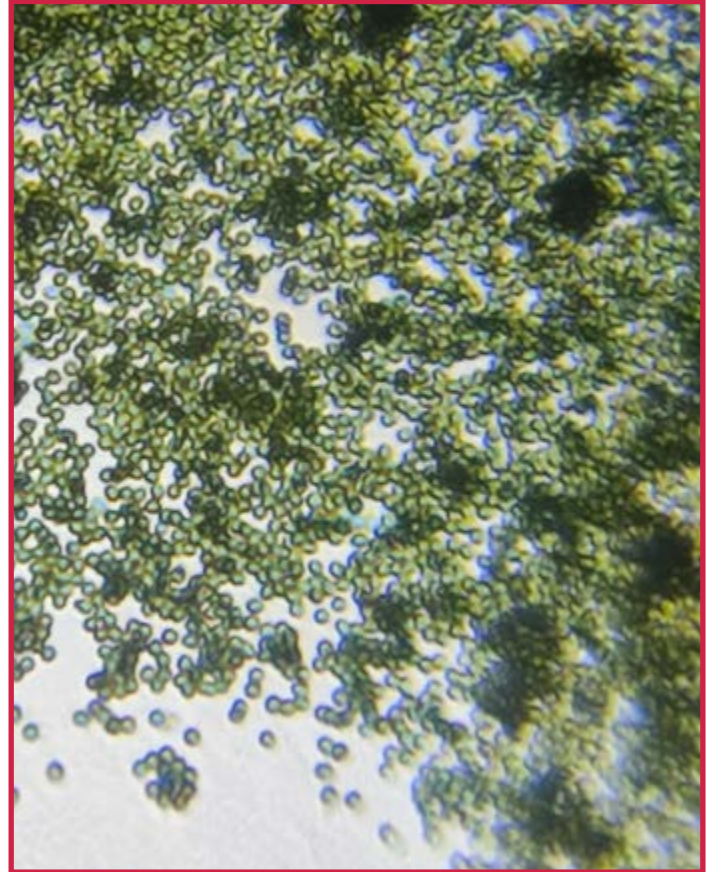


Blast disease of rice



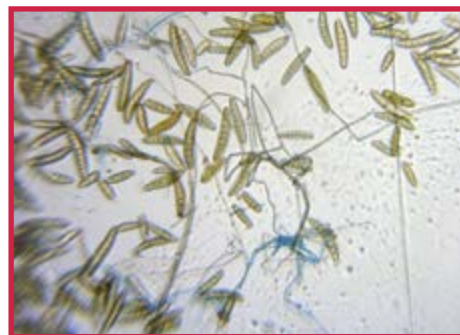
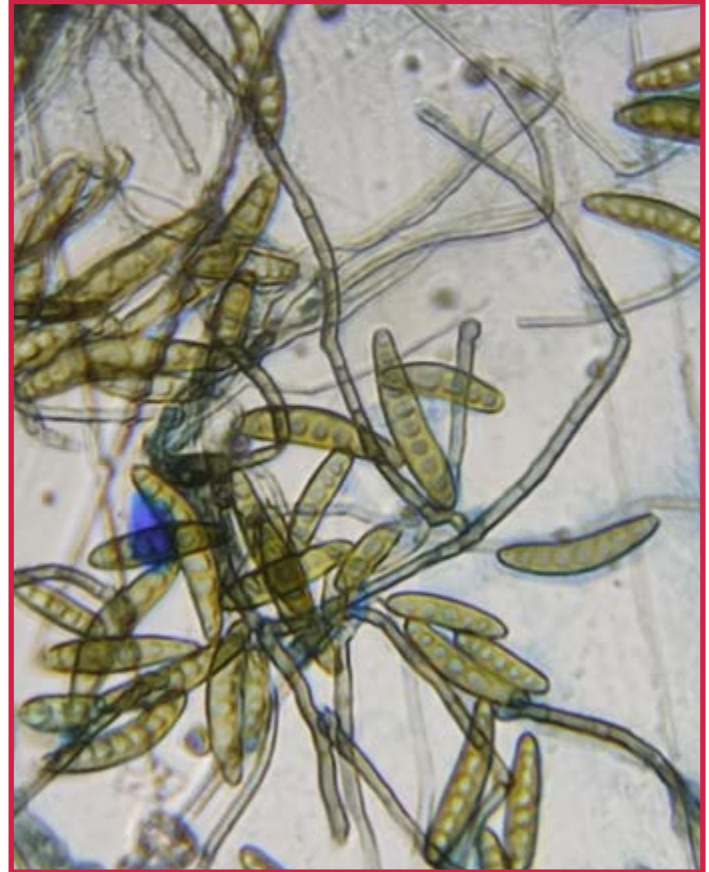
In situ diagnosis of *Magnaporthe oryzae* (Blast disease of rice) under Foldscope

False smut disease of rice



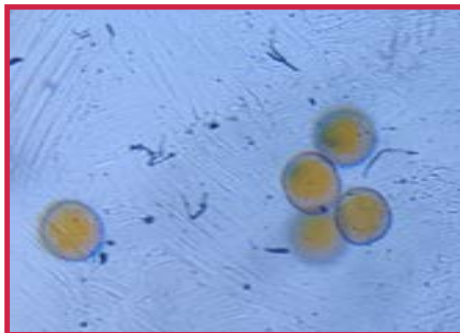
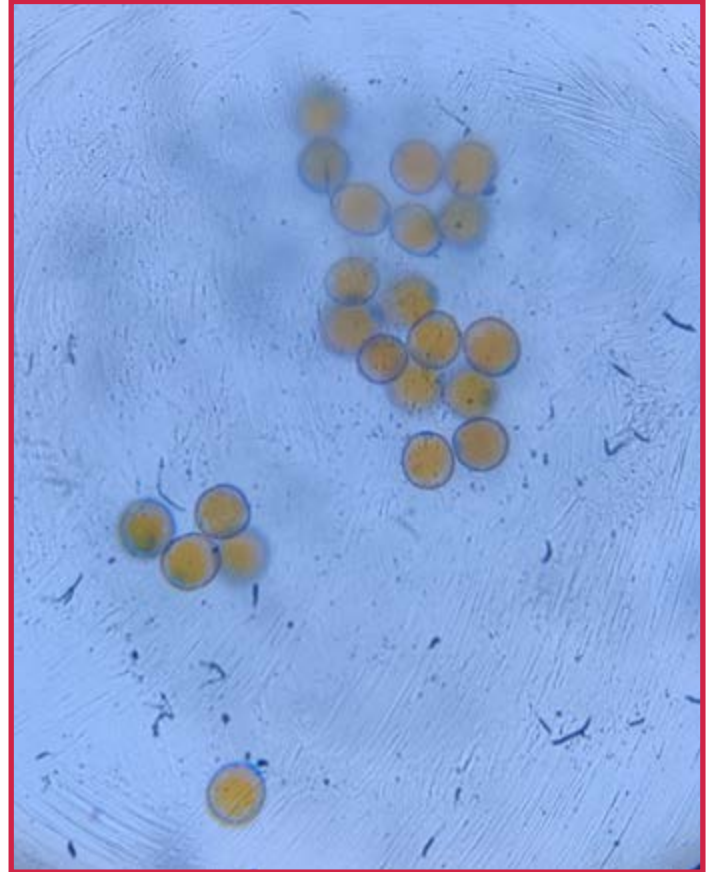
In situ diagnosis of *Ustilagoideae virens* (False smut disease of rice) under Foldscope

Brown spot disease of rice



In situ diagnosis of *Helminthosporium* spp (Brown spot disease of rice) under Foldscope

Brown rust disease of wheat



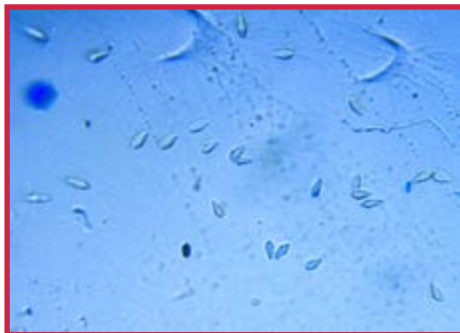
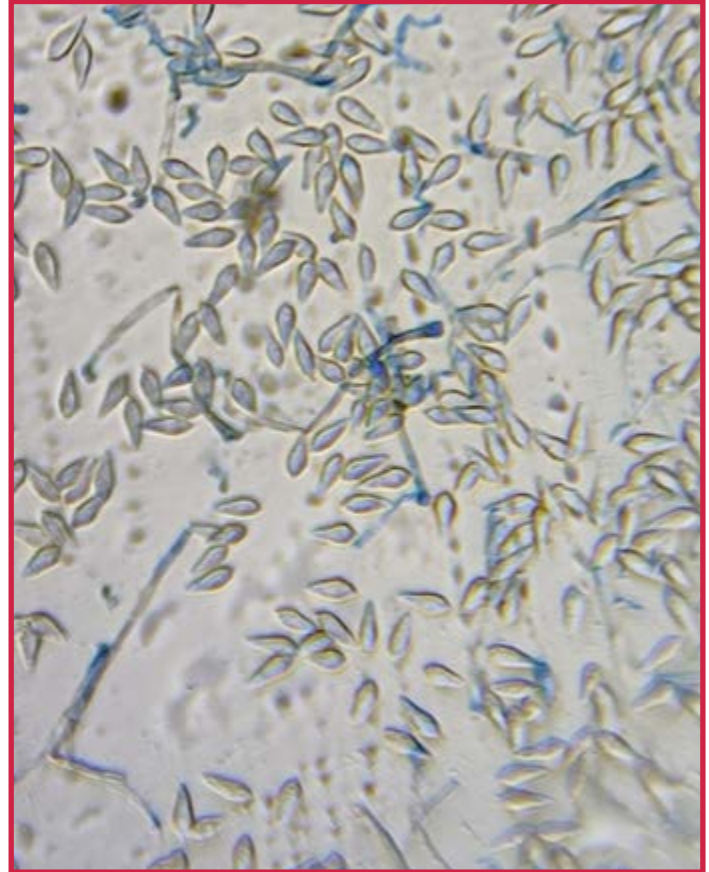
In situ diagnosis of *Puccinia* spp (Brown rust disease of wheat) under Foldscope

Loose smut disease of wheat



In situ diagnosis of *Ustilago tritici* (Loose smut disease of wheat) under Foldscope

Blast disease of finger millet



In situ diagnosis of *Magnaporthe grisea* (Blast disease of finger millet) under Foldscope

Wheat seed (Seed pathogen)



In situ diagnosis of *Curvularia* spp (Wheat seed) under Foldscope

Wheat seed (Seed pathogen)



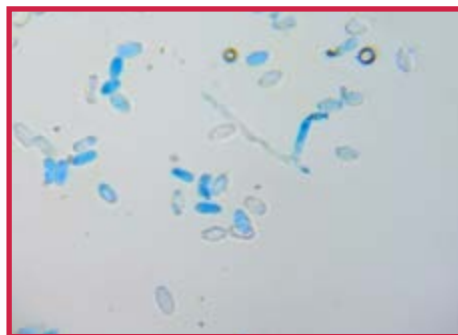
In situ diagnosis of *Helminthosporium* spp (Wheat seed) under Foldscope

(B) Disease of Pulse Crops

S. No.	Name of Disease	Identified Pathogen (Organism)
1	Powdery mildew disease of mungbean	<i>Erysiphe</i> spp
2	Powdery mildew disease of blackgram	<i>Erysiphe polygoni</i>
3	Root rot disease of chickpea	<i>Rhizoctonia</i> spp
4	Rust disease of chickpea	<i>Uromyces</i> spp

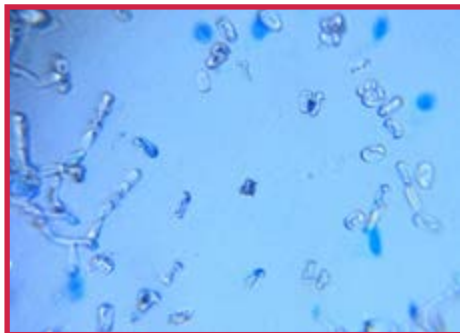


Powdery mildew disease of mungbean



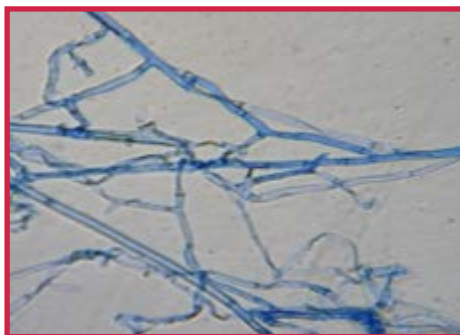
In situ diagnosis of *Erysiphe* spp (Powdery mildew disease of mungbean) under Foldscope

Powdery mildew disease of blackgram



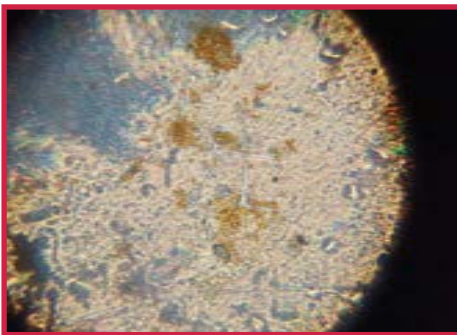
In situ diagnosis of *Erysiphe polygoni* (Powdery mildew disease of blackgram) under Foldscope

Root rot disease of chickpea



In situ diagnosis of *Rhizoctonia* spp (Root rot disease of chickpea) under Foldscope

Rust disease of chickpea



In situ diagnosis of *Uromyces* spp (Rust disease of chickpea) under Foldscope

(C) Disease of Oilseed Crops

S. No.	Name of Disease	Identified Pathogen (Organism)
1	Leaf blight disease of linseed	<i>Alternaria lini</i>
2	Powdery mildew disease of sunflower	<i>Golovinomyces cichoracearum</i>
3	Leaf blight of safflower	<i>Alternaria carthemi</i>
4	Alternaria leaf blight of mustard	<i>Alternaria</i> spp

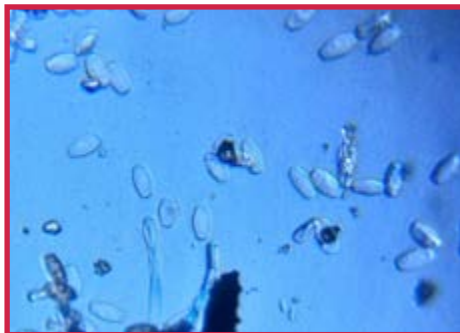
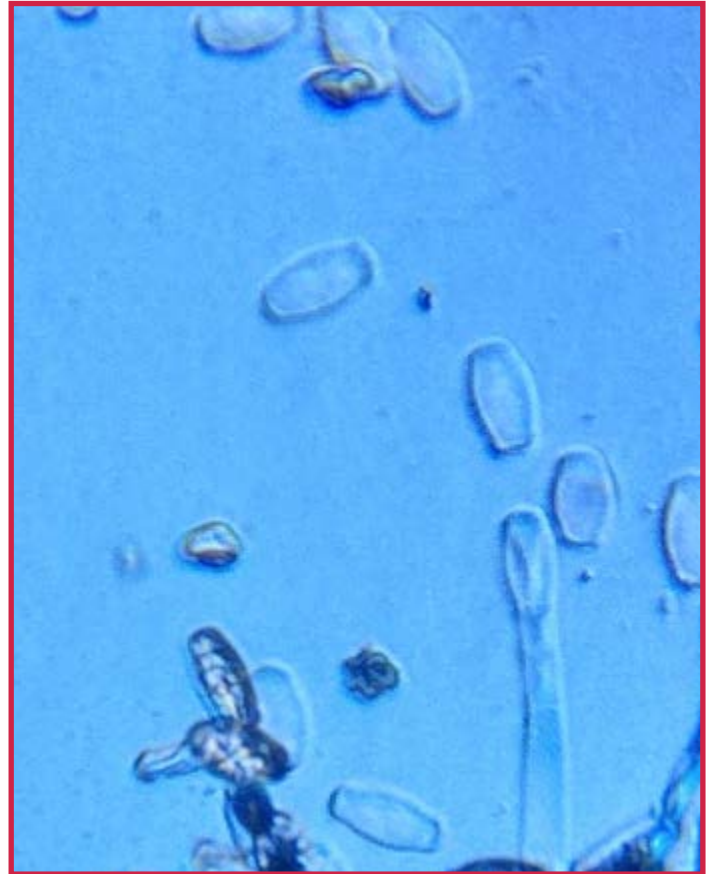


Leaf blight disease of linseed



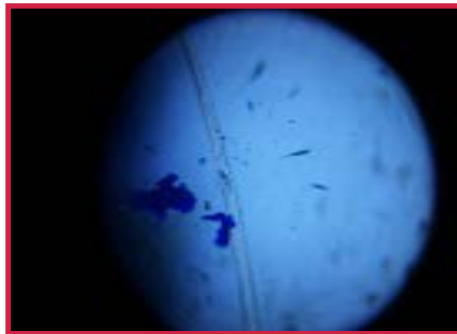
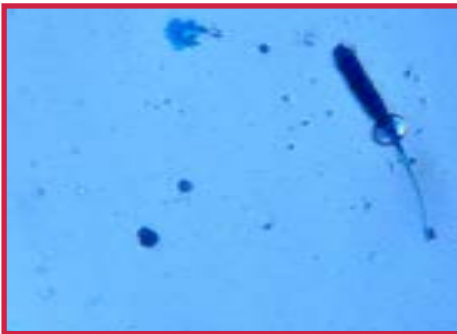
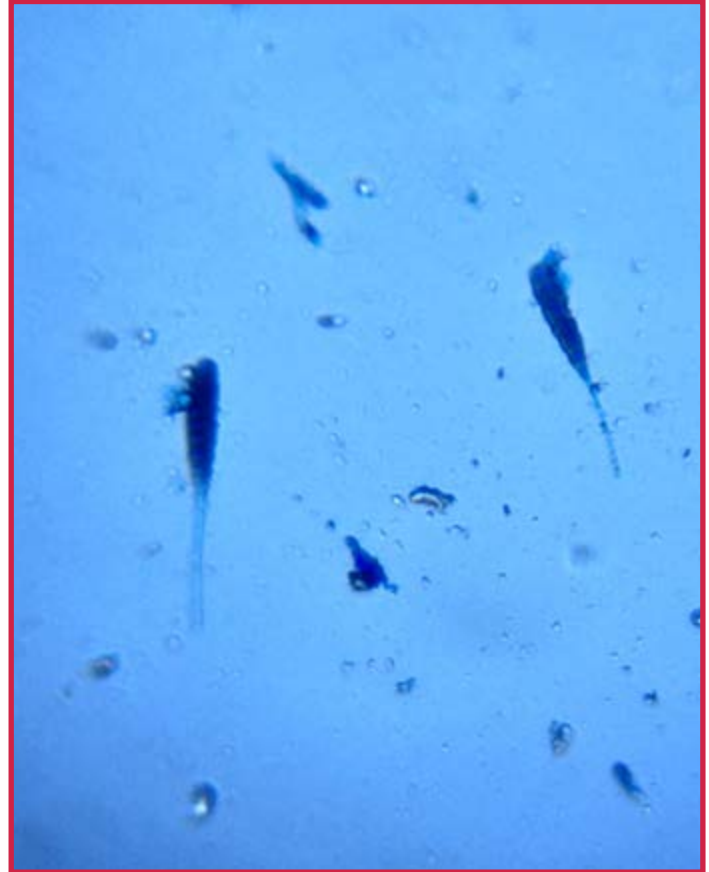
In situ diagnosis of *Alternaria lini* (Leaf blight disease of linseed) under Foldscope

Powdery mildew disease of sunflower



In situ diagnosis of *Golovinomyces cichoracearum* (Powdery mildew disease of sunflower) under Foldscope

Leaf blight of safflower



In situ diagnosis of *Alternaria carthemi* (Leaf blight of safflower) under Foldscope

Alternaria leaf blight of mustard



In situ diagnosis of *Alternaria* spp (Alternaria leaf blight of mustard) under Foldscope

(D) Disease of Horticultural Crops

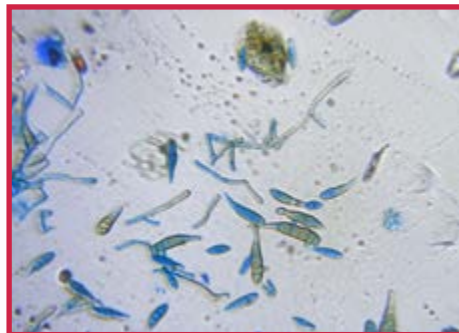
S. No.	Name of Disease	Identified Pathogen (Organism)
1	White rust disease of Amaranthus	<i>Albugo bliti</i>
2	Early blight of tomato	<i>Alternaria solani</i>
3	Damping off disease of tomato	<i>Fusarium spp</i>
4	Seedling blight disease of tomato	<i>Rhizopus spp</i>
5	Powdery mildew disease of muskmelon	<i>Erysiphe cichoracearum</i>
6	Powdery mildew disease of coriander	<i>Erysiphe spp</i>
7	Powdery mildew disease of fenugreek	<i>Leveillula taurica</i>
8	Purple blotch of onion	<i>Alternaria porri</i>
9	Alternaria leaf blight of cabbage	<i>Alternaria spp</i>
10	Alternaria leaf blight of brinjal	<i>Alternaria spp</i>
11	Leaf spot of okra	<i>Cercospora spp</i>
12	Powdery mildew disease of cucurbits	<i>Erysiphe spp</i>
13	Leaf blight of ash gourd	<i>Alternaria spp</i>
14	Botrytis blight of brinjal	<i>Botrytis spp</i>
15	Powdery mildew disease of ber	<i>Oidium erysiphoides</i>
16	Red rust disease of mango	<i>Cephaleuros virescens</i>

White rust disease of Amaranthus



In situ diagnosis of *Albugo bliti* (White rust disease of Amaranthus) under Foldscope

Early blight of tomato



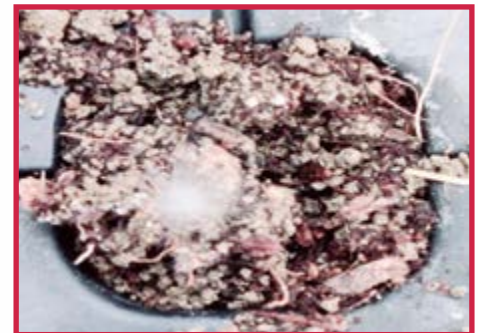
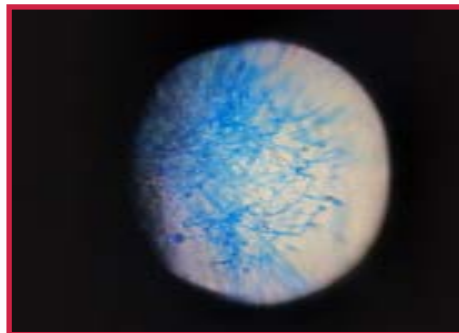
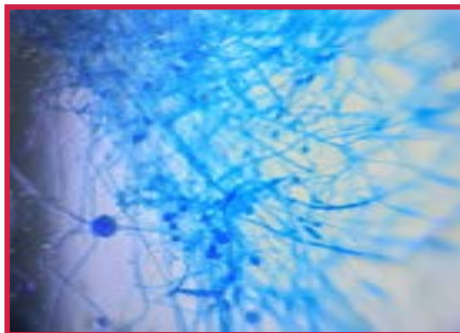
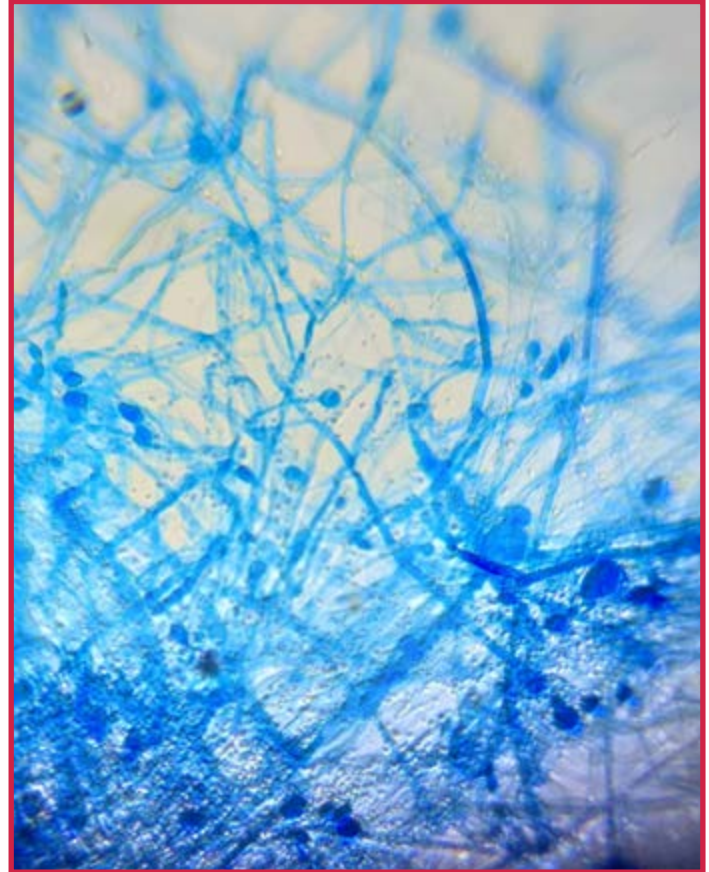
In situ diagnosis of *Alternaria solani* (Early blight of tomato) under Foldscope

Damping off disease of tomato



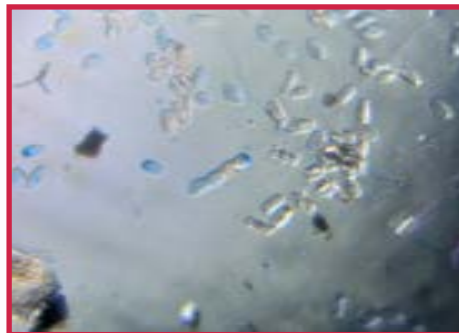
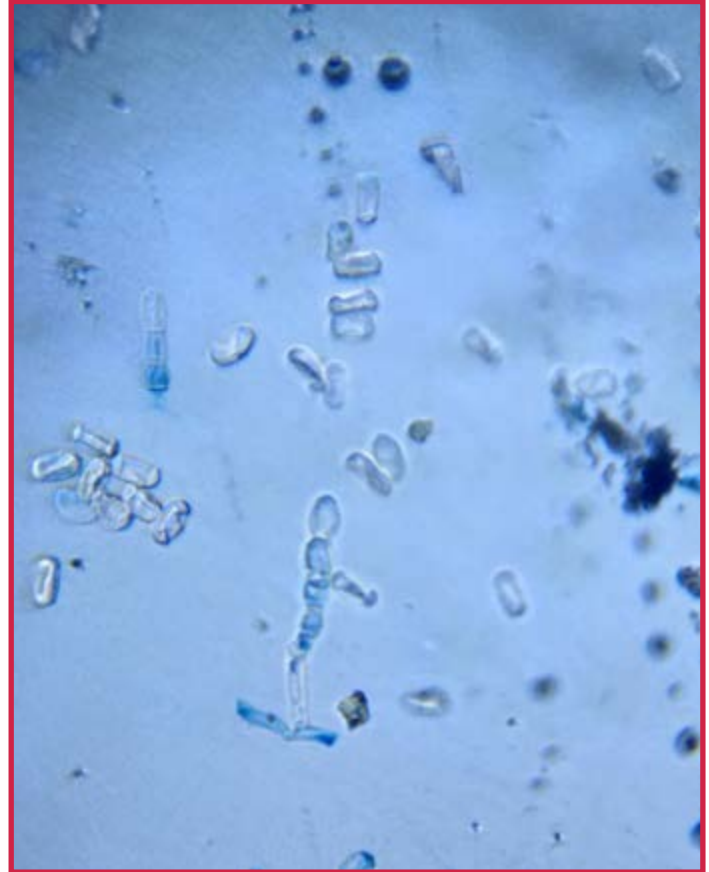
In situ diagnosis of *Fusarium* spp (Damping off disease of tomato) under Foldscope

Seedling blight disease of tomato



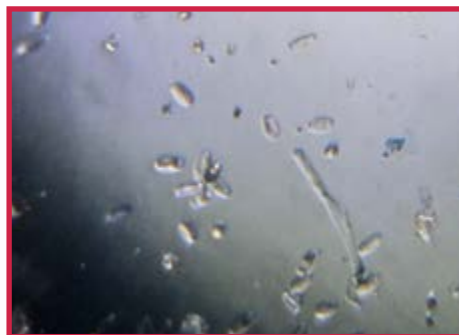
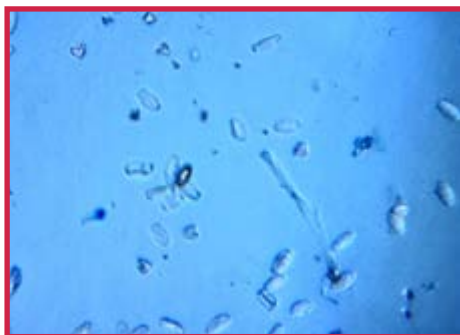
In situ diagnosis of *Rhizopus* spp (Seedling blight disease of tomato) under Foldscope

Powdery mildew disease of muskmelon



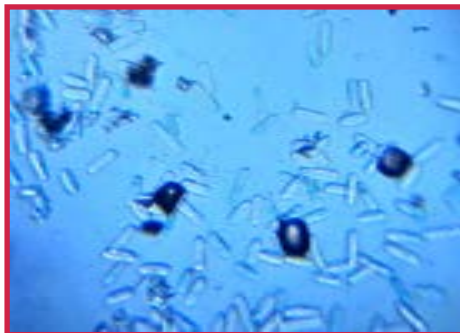
In situ diagnosis of *Erysiphe cichoracearum* (Powdery mildew disease of muskmelon) under Foldscope

Powdery mildew disease of coriander



In situ diagnosis of *Erysiphe* spp (Powdery mildew disease of coriander) under Foldscope

Powdery mildew disease of fenugreek



In situ diagnosis of *Leveillula taurica* (Powdery mildew disease of fenugreek) under Foldscope

Purple blotch of onion



In situ diagnosis of *Alternaria porri* (Purple blotch of onion) under Foldscope

Alternaria leaf blight of cabbage



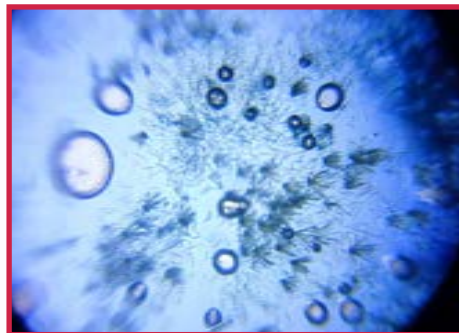
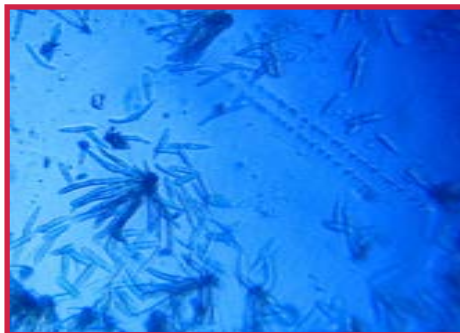
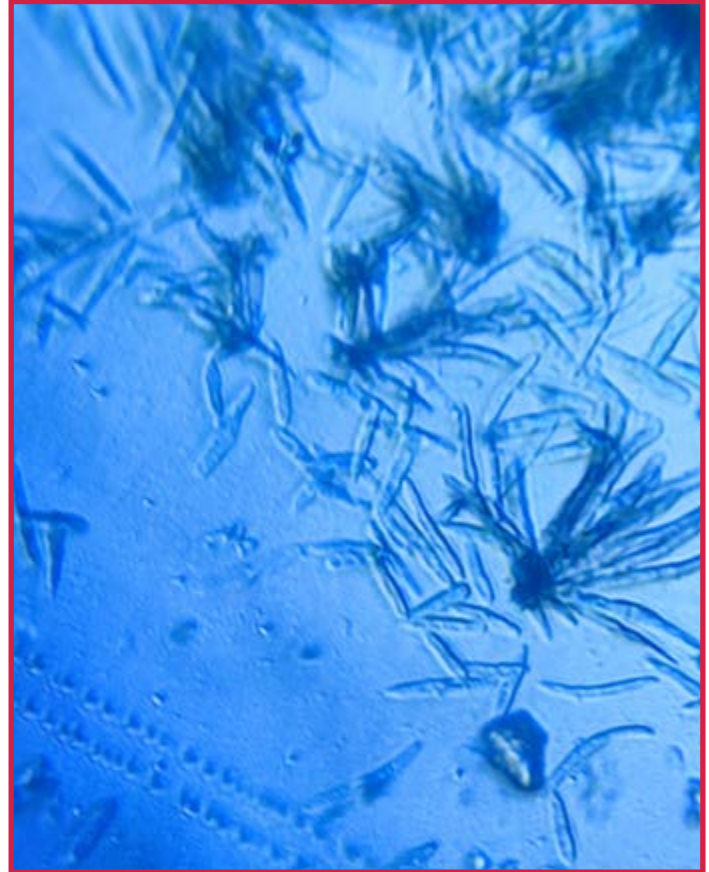
In situ diagnosis of *Alternaria* spp (Alternaria leaf blight of cabbage) under Foldscope

Alternaria leaf blight of brinjal



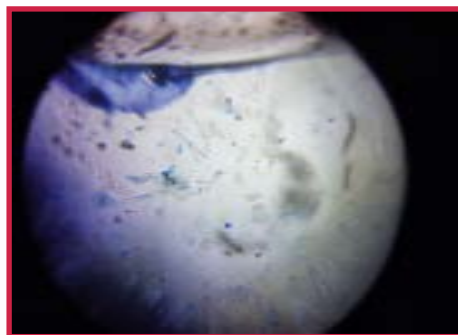
In situ diagnosis of *Alternaria* spp (Alternaria leaf blight of brinjal) under Foldscope

Leaf spot of okra



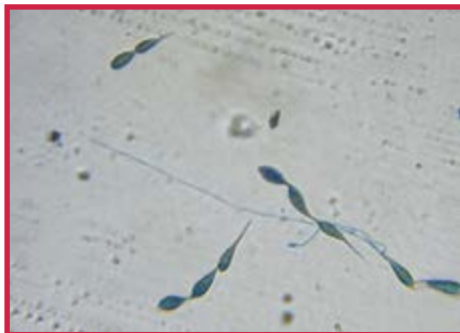
In situ diagnosis of *Cercospora* spp (Leaf spot of okra) under Foldscope

Powdery mildew disease of cucurbits



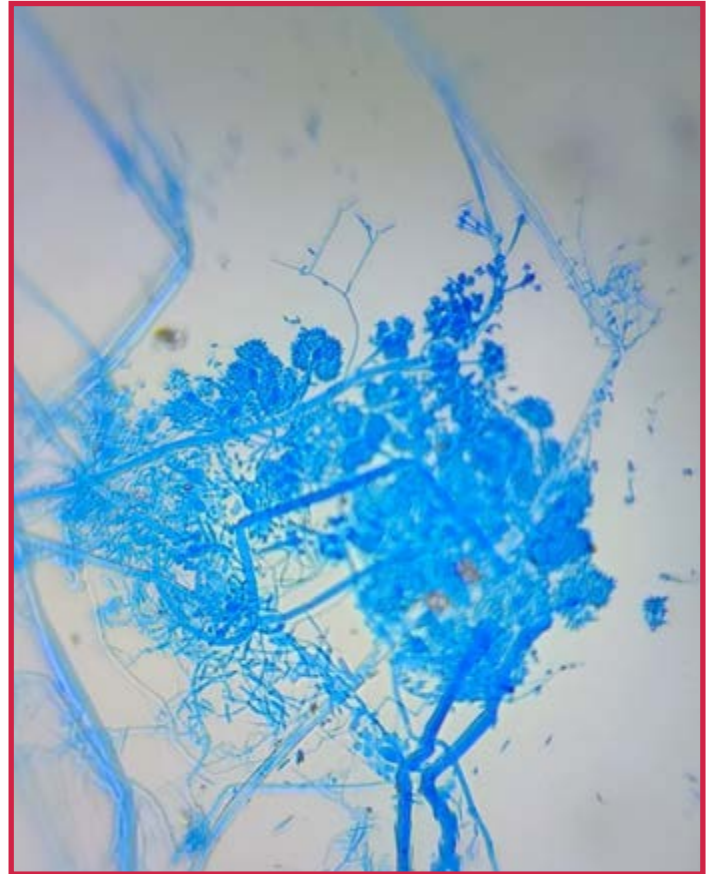
In situ diagnosis of *Erysiphe* spp (Powdery mildew disease of cucurbits) under Foldscope

Leaf blight of ash gourd



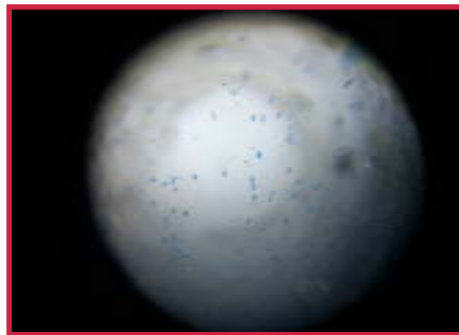
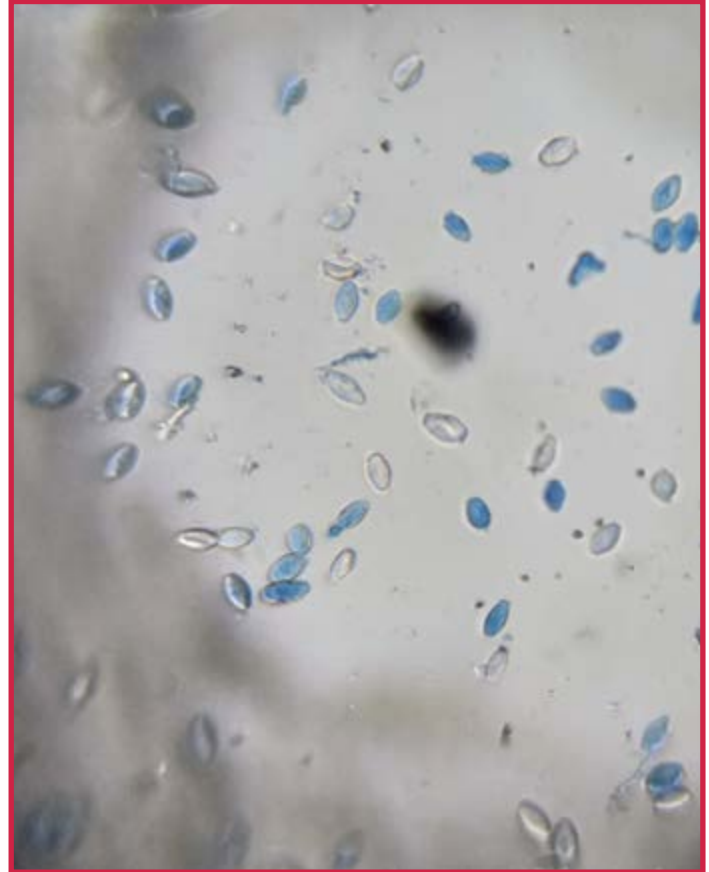
In situ diagnosis of *Alternaria* spp (Leaf blight of ash gourd under Foldscope)

Botrytis blight of brinjal



In situ diagnosis of *Botrytis* spp (Botrytis blight of brinjal) under Foldscope

Powdery mildew disease of ber



In situ diagnosis of *Oidium erysiphoides* (Powdery mildew disease of ber) under Foldscope

Red rust disease of mango



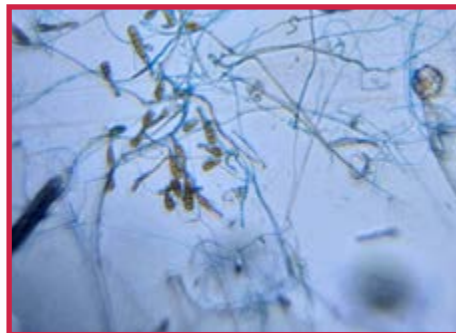
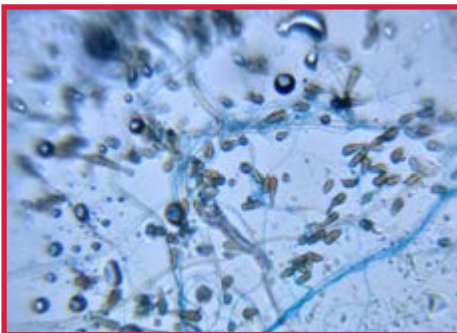
In situ diagnosis of *Cephaleuros virescens* (Red rust disease of mango) under Foldscope

(E) Post-Harvest Disease of Horticultural Crops

S. No.	Name of Disease	Identified Pathogen (Organism)
1	Post-harvest fruit rot disease of mango	<i>Alternaria</i> spp
2	Green mould disease of citrus	<i>Penicillium digitatum</i>
3	Fruit rot disease of grape	<i>Aspergillus</i> spp
4	Black mould disease of onion	<i>Aspergillus</i> spp
5	Black mould disease of Garlic	<i>Aspergillus</i> spp

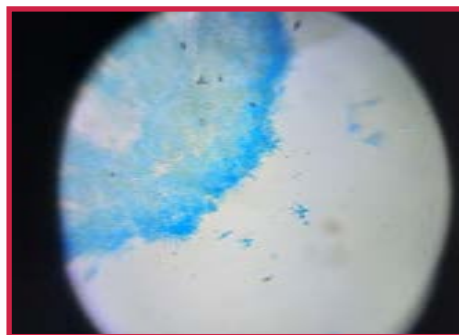
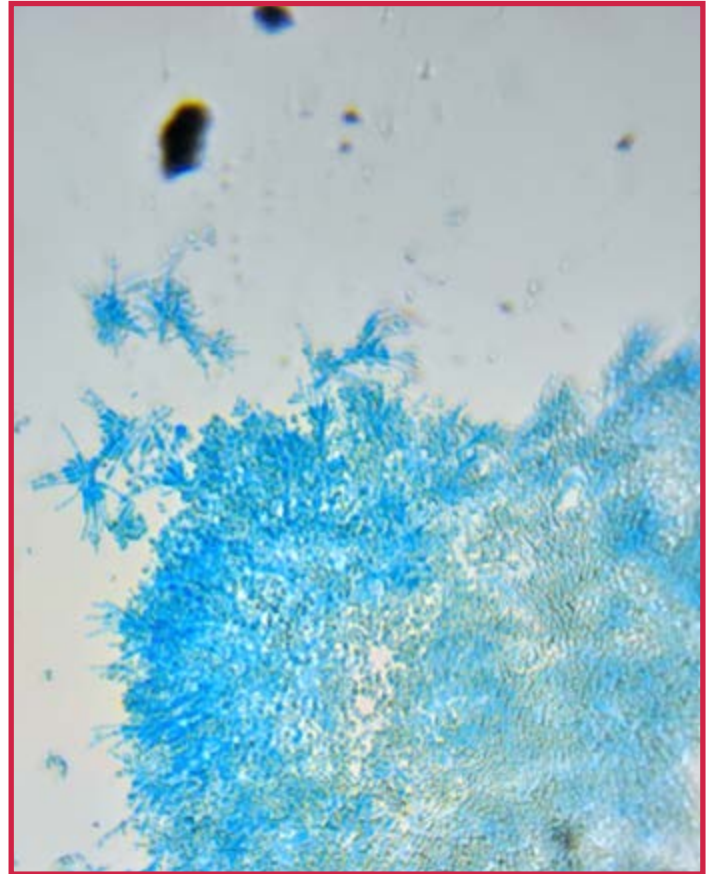


Post-harvest fruit rot disease of mango



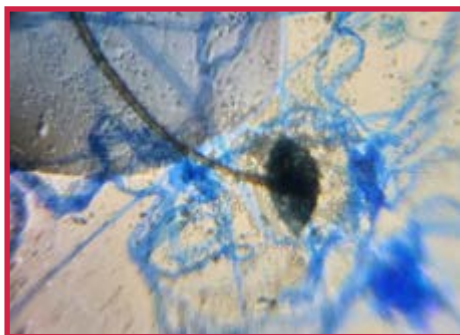
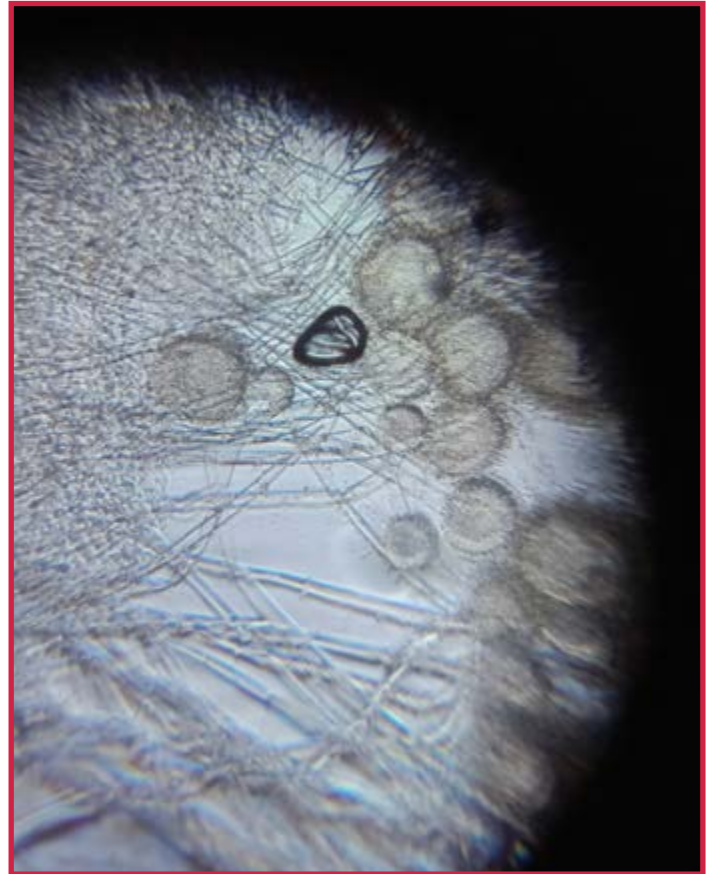
In situ diagnosis of *Alternaria* spp (Post-harvest fruit rot disease of mango) under Foldscope

Green mould disease of citrus



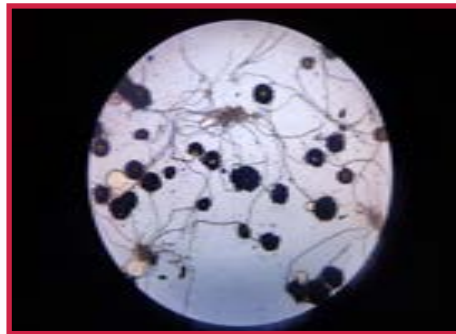
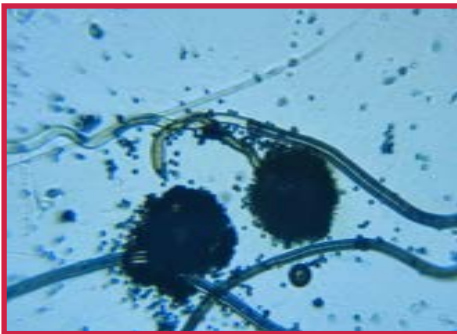
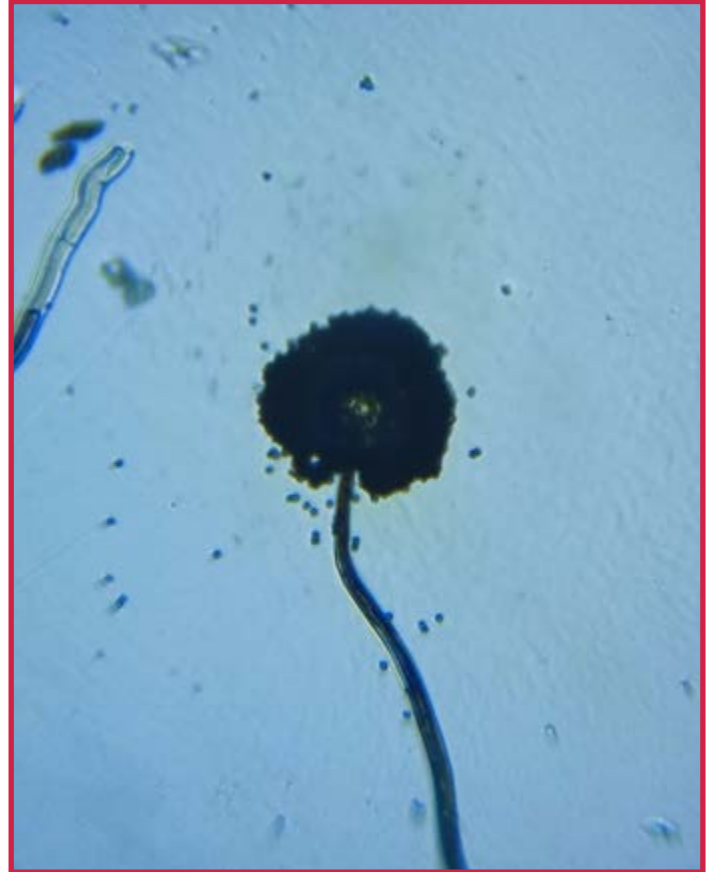
In situ diagnosis of *Penicillium digitatum* (Green mould disease of citrus) under Foldscope

Fruit rot disease of grape



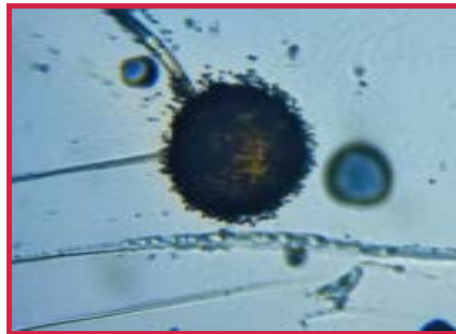
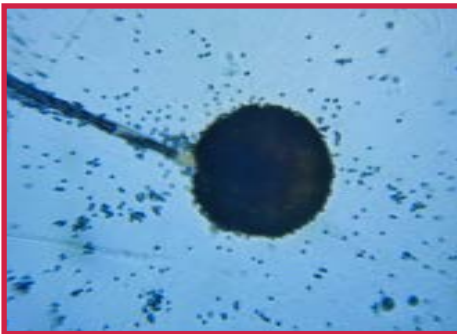
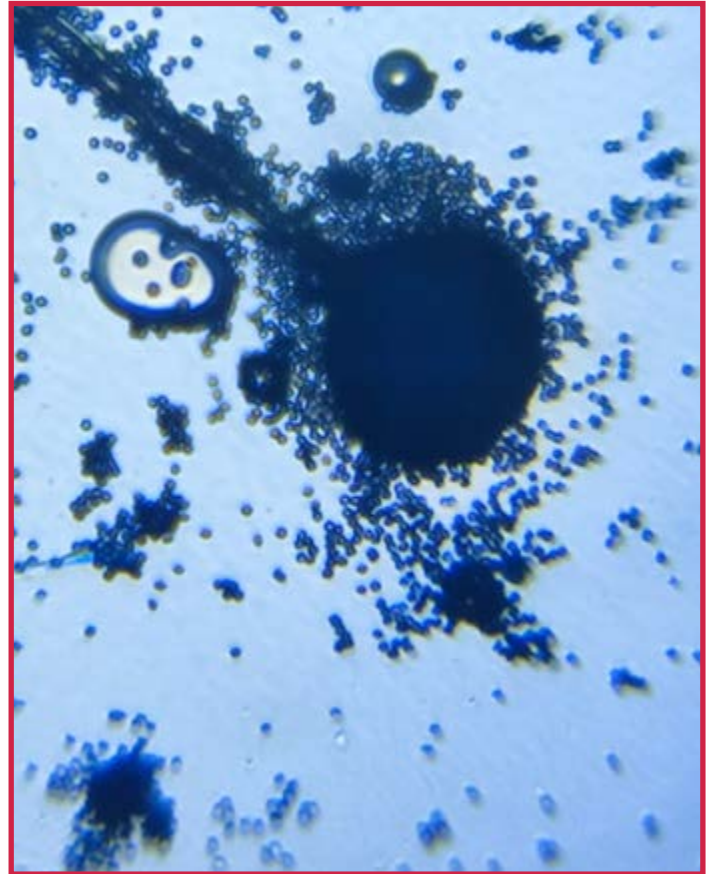
In situ diagnosis of *Aspergillus* spp (Fruit rot disease of grape) under Foldscope

Black mould disease of onion



In situ diagnosis of *Aspergillus* spp (Black mould disease of onion) under Foldscope

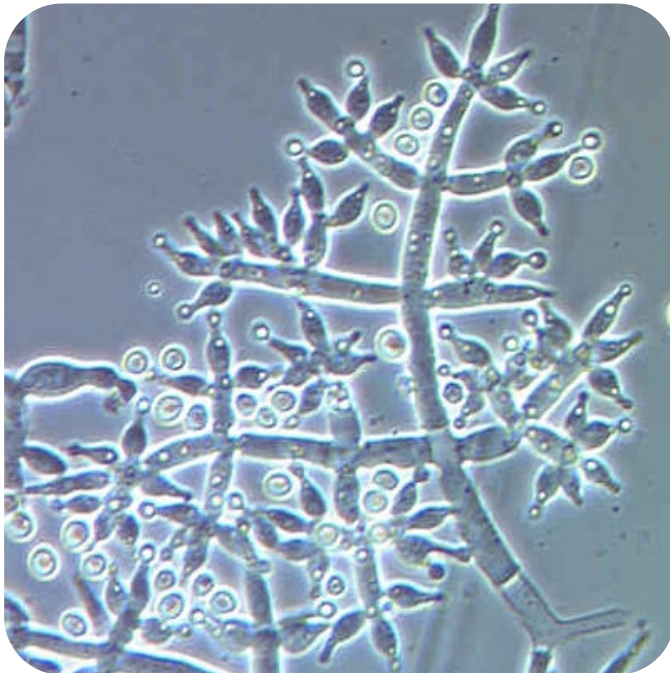
Black mould disease of garlic



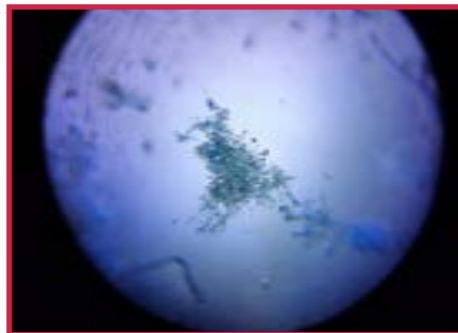
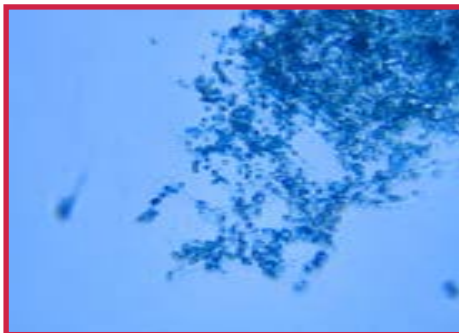
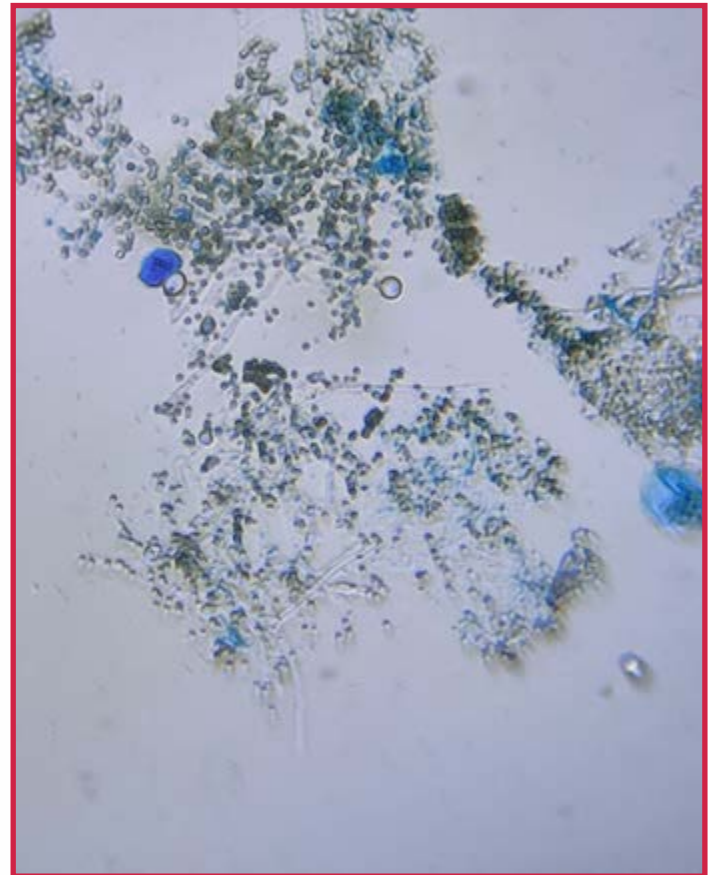
In situ diagnosis of *Aspergillus* spp (Black mould disease of garlic) under Foldscope

(F) Viability test of Bioagent

S. No.	Name of Disease	Identified Pathogen (Organism)
1	Indira Trichoderma (Bio fungicide)	<i>Trichoderma</i> spp
2	Entomopathogen (Pacelomyces)	<i>Pacelomyces</i> spp

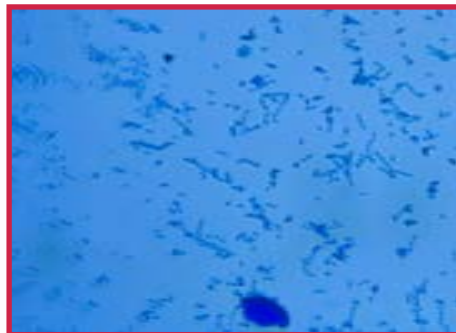
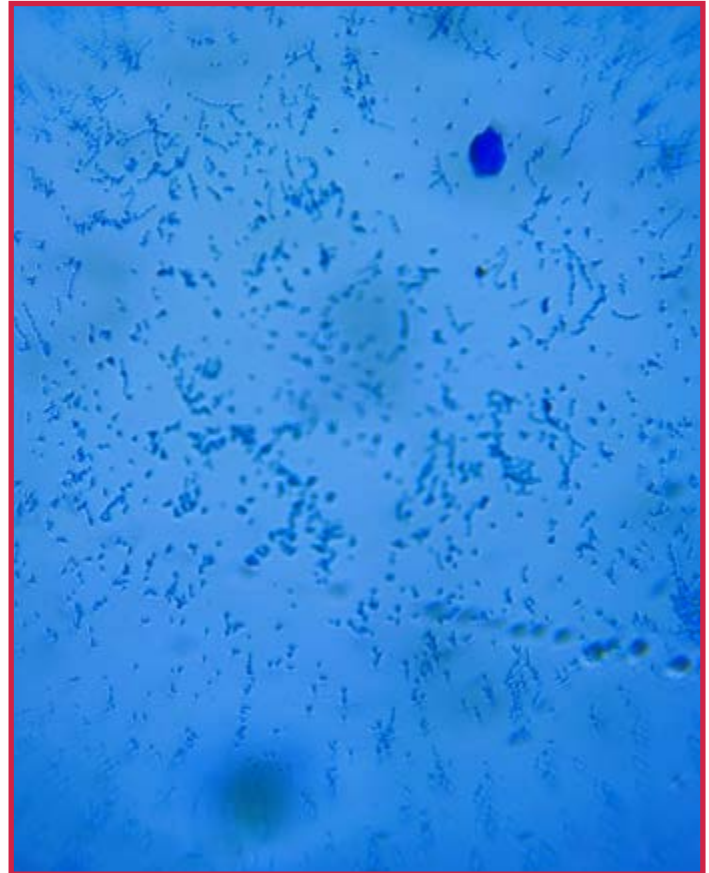


Indira Trichoderma (Bio fungicide)



In situ viability test of *Trichoderma* spp (Indira Trichoderma) under Foldscope

Entomopathogen (Pacelomyces)



In situ viability test of *Pacelomyces* spp (Entomopathogen) under Foldscope

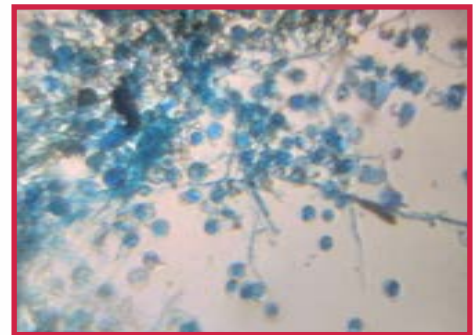
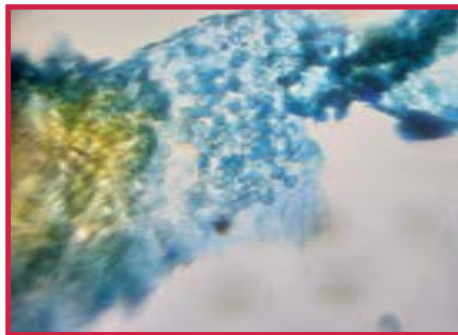
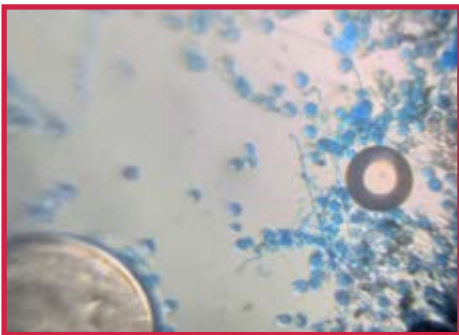
Ex situ diagnosis

(A) Plant Disease

S. No.	Name of Disease	Identified Pathogen (Organism)
1	White rust of amaranthus	<i>Albugo bliti</i>
2	Downy mildew of cauliflower	<i>Peronospora parasitica</i>
3	Black spot disease of rose	<i>Diplocarpon rosae</i>
4	Powdery mildew disease of shisham	<i>Ovulariopsis sissoo</i>
5	Wheat seed (Seed pathogen)	<i>Rhizopus spp</i>

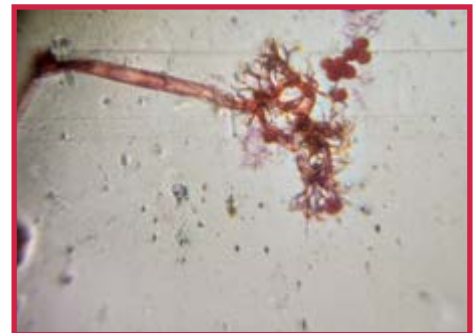
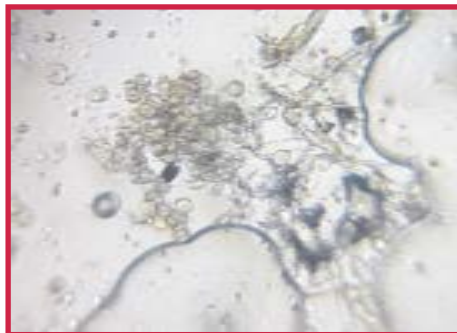
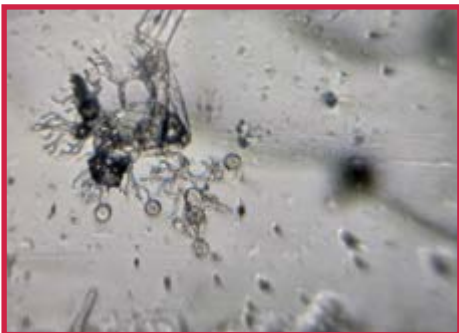


White rust of amaranthus



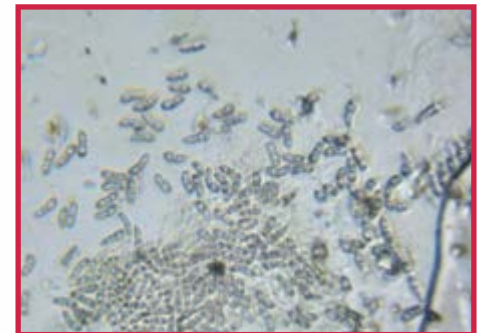
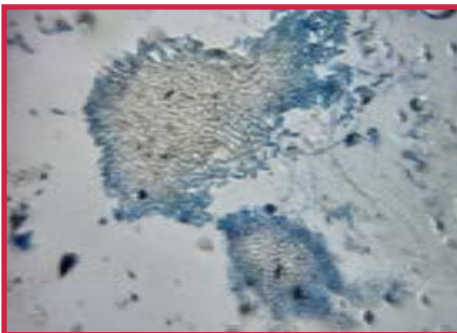
Diagnosis of *Albugo bliti* (White rust of amaranthus) under Foldscope

Downy mildew of cauliflower



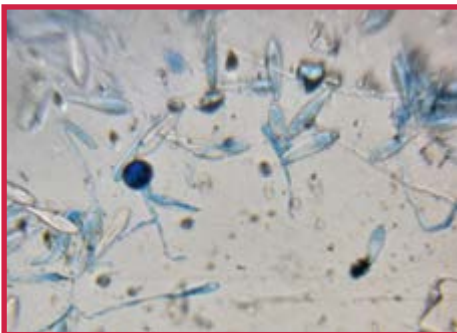
Diagnosis of *Peronospora parasitica* (Downy mildew of cauliflower) under Foldscope

Black spot disease of rose



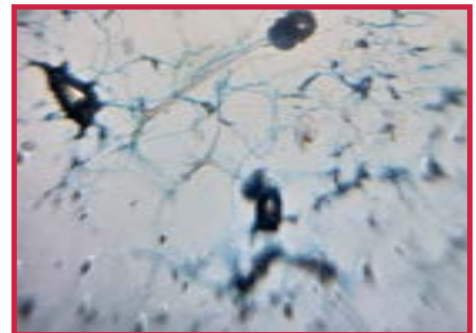
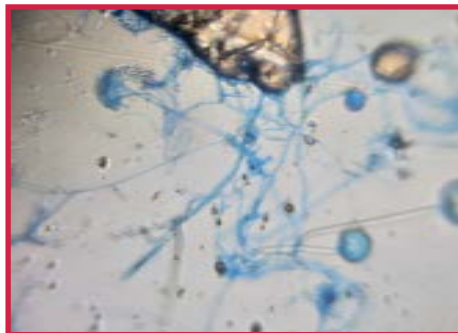
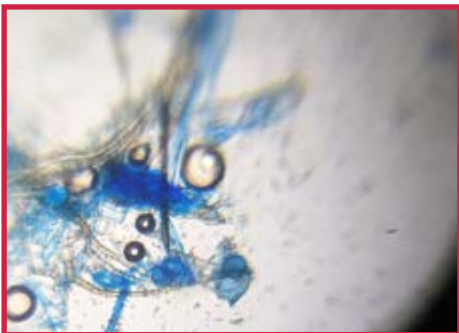
Diagnosis of *Diplocarpon rosae* (Black spot disease of rose) under Foldscope

Powdery mildew disease of shisham



Diagnosis of *Ovulariopsis sissou* (Powdery mildew disease of shisham) under Foldscope

Wheat seed (Seed pathogen)



Diagnosis of *Rhizopus* spp (Wheat seed (Seed pathogen)) under Foldscope

(B) Insect and Nematodes

S. No.	Name of Insect/ Pest	Identified Organism (Scientific Name)
1	Aphid	<i>Aphis gossypii</i>
2	Leaf mite	<i>Oligonychus</i> spp
3	Trichogramma (Parasitoid)	<i>Trichogramma japonicum</i>
4	Root knot nematode of brinjal	<i>Meloidogyne</i> spp

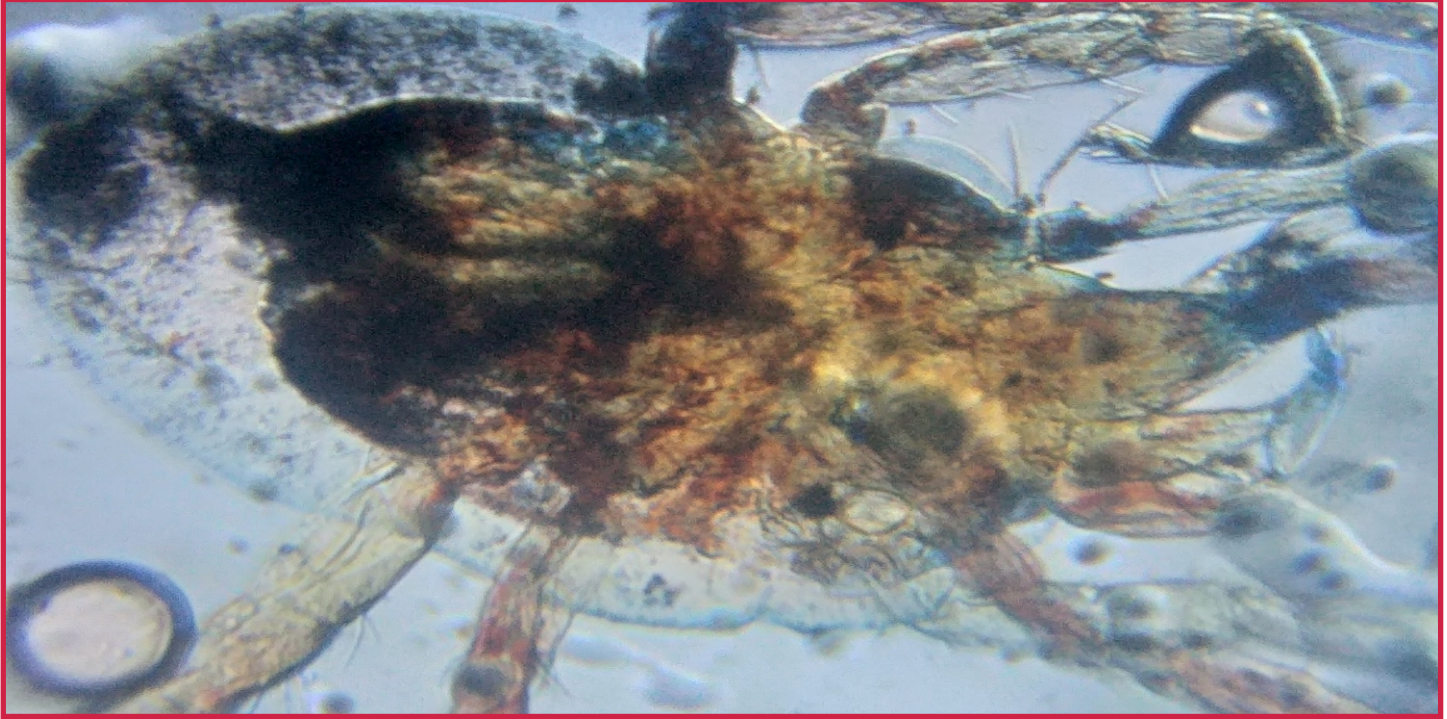


Aphid



Diagnosis of *Aphis gossypii* (Aphid) under Foldscope

Leaf mite



Diagnosis of *Oligonychus* spp (Leaf mite) under Foldscope

Trichogramma (Parasitoid)



Diagnosis of *Trichogramma japonicum* (Trichogramma (Parasitoid)) under Foldscope

Root knot nematode of brinjal



Diagnosis of *Meloidogyne* spp (Root knot nematode of brinjal) under Foldscope

(C) Zoonotic Disease

S. No.	Name of Disease	Identified Organism (Scientific Name)
1	Candidiasis disease	<i>Candida</i> spp
2	Mastitis milk of cow	<i>Rhizopus</i> spp

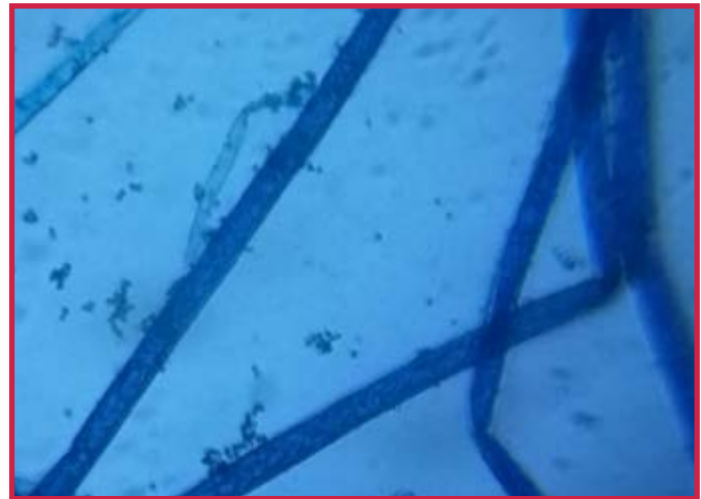
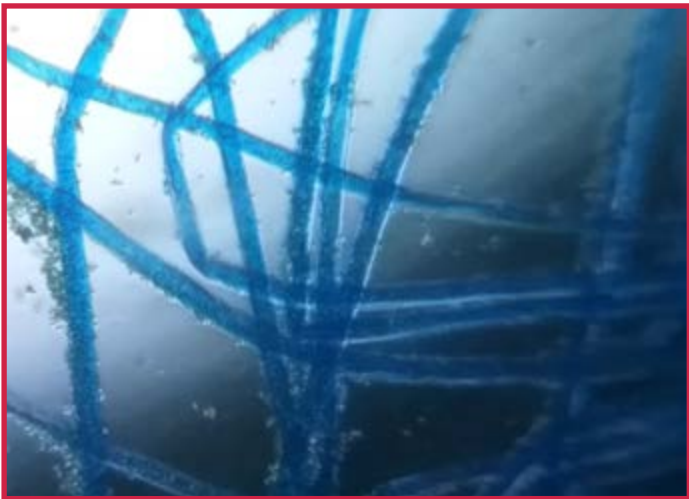


Candidiasis disease



Diagnosis of *Candida* spp (Candidiasis disease) under Foldscope

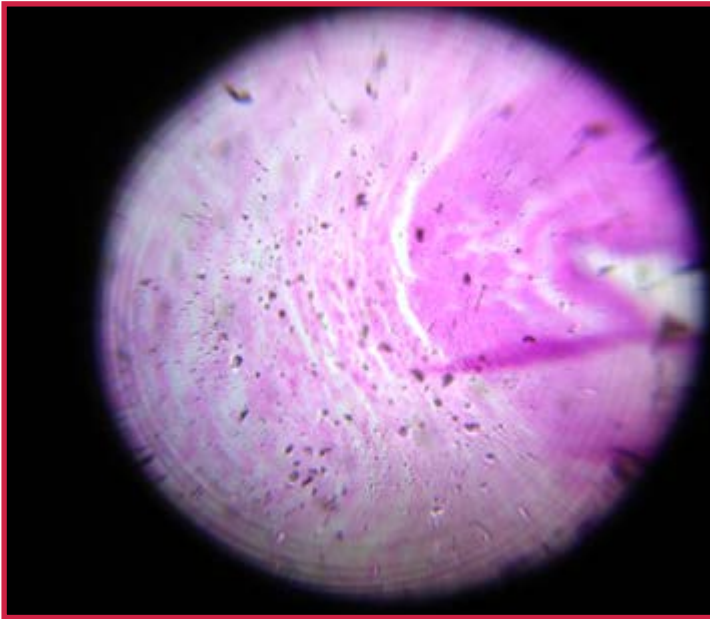
Mastitis milk of cow



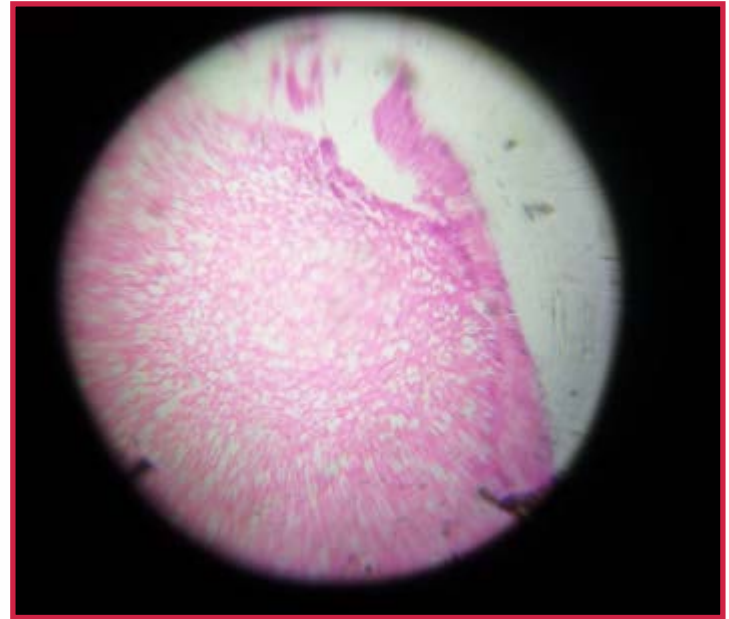
Diagnosis of *Rhizopus* spp (Mastitis milk of cow) under Foldscope

(D) Histology

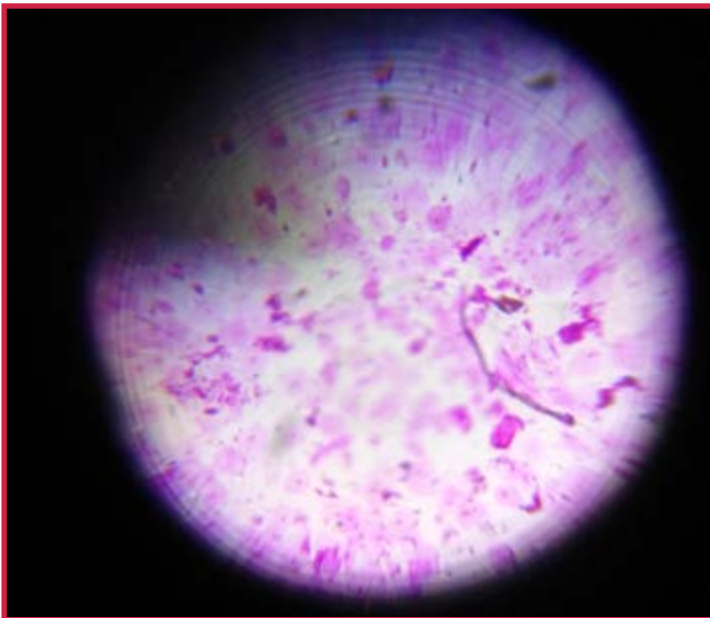
S. No.	Name of tissue	S. No.	Name of tissue
1	Connective Tissue	16	Artery T.S.
2	Nerve Tissue	17	Cuboidal Epithelium
3	Animal Cell	18	Heart T.S.
4	Elastic Cartilage	19	Hyaline Cartilage T.S.
5	Epithelium	20	Smooth Muscles T.S.
6	Large Intestine T. S.	21	Spinal Cord T. S.
7	Mammal Lung T. S.	22	Nerve Cell T.S.
8	Tongue T. S.	23	Large Intestine T. S
9	Uterus T. S.	24	Small Intestine T.S.
10	Cardiac Muscles T. S.	25	Spleen T.S.
11	Kidney T.S.	26	Squamous Epithelium
12	Spinal Cord T. S.	27	Stomach T.S.
13	Skin T.S.	28	Blood smear
14	Colon (Rectum)T.S	29	Mammal Oesophagus T.S.
15	Aorta T.S.	30	Ascaris Male T. S.



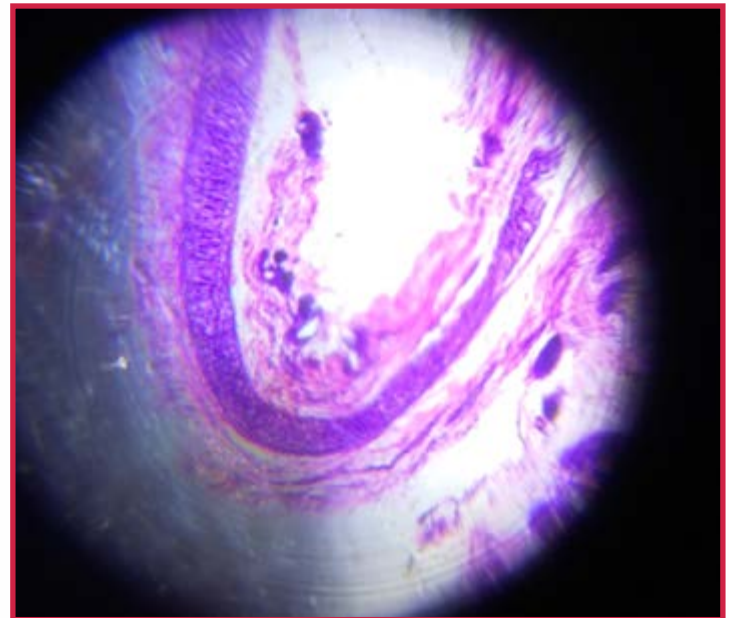
1. Connective Tissue



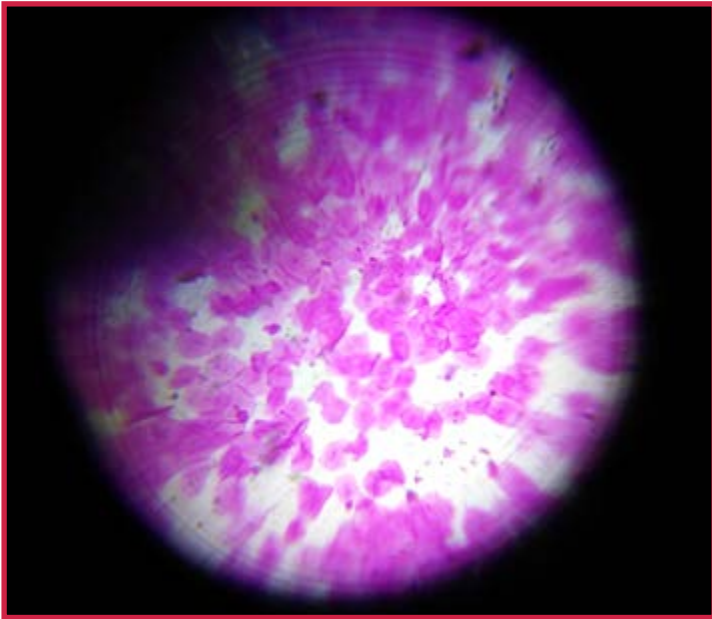
2. Nerve Tissue



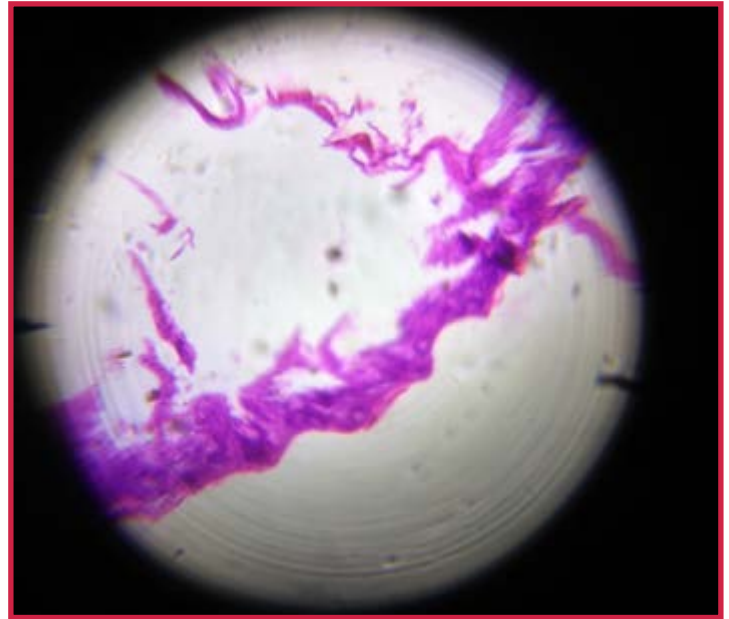
3. Animal Cell



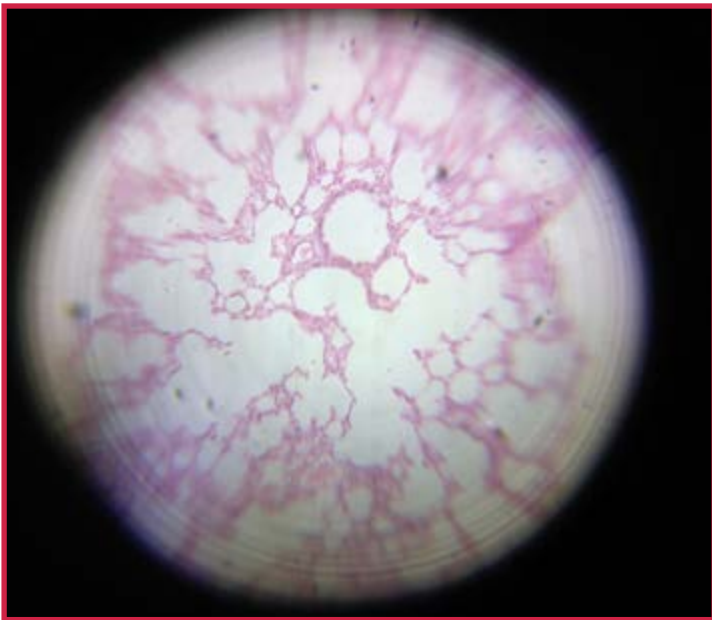
4. Elastic Cartilage



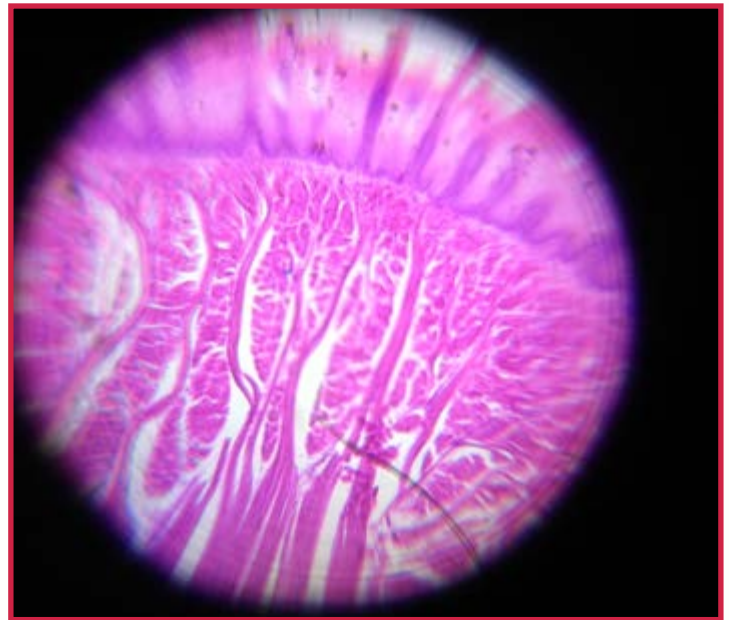
5. Epithelium



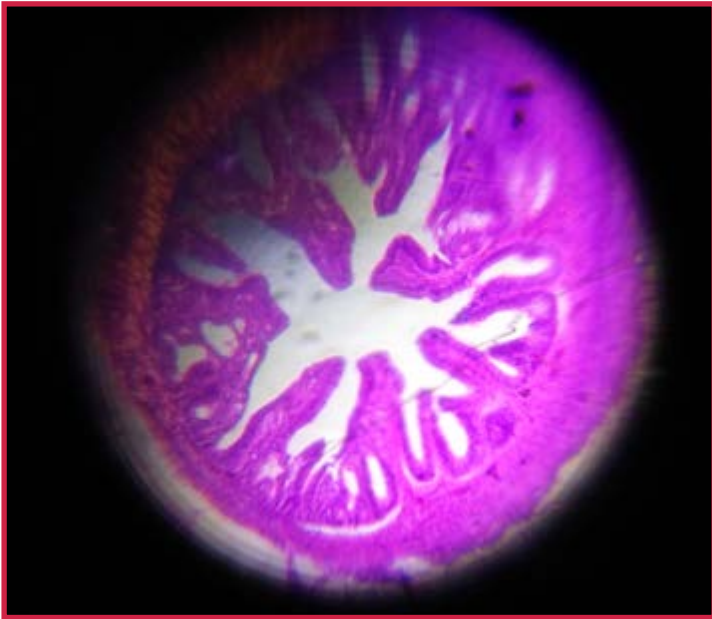
6. Large Intestine T. S.



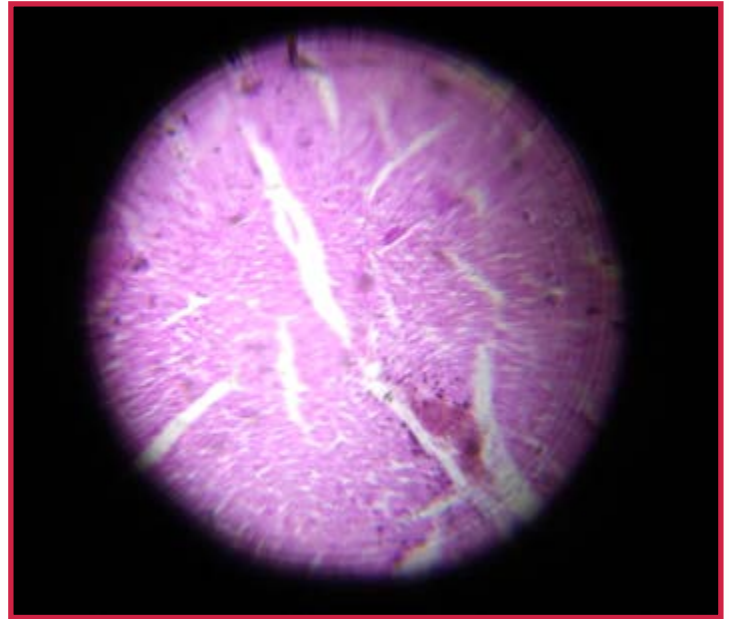
7. Mammal Lung T. S.



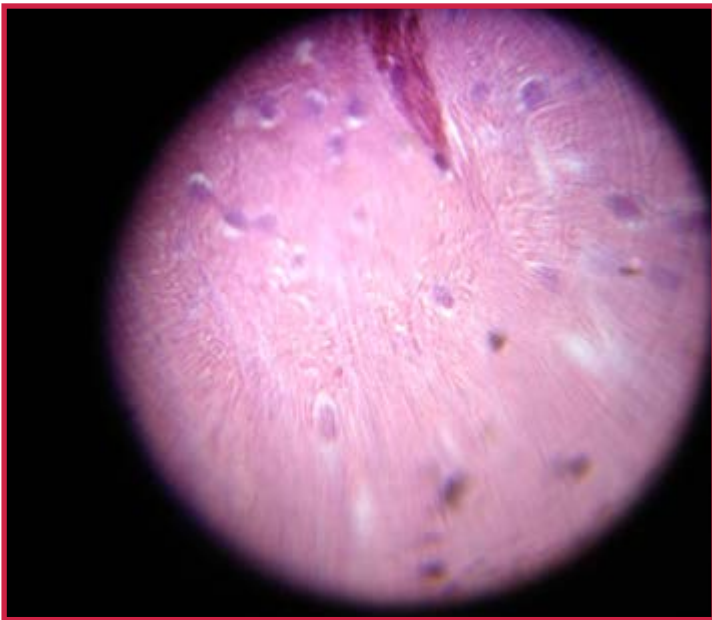
8. Tongue T. S.



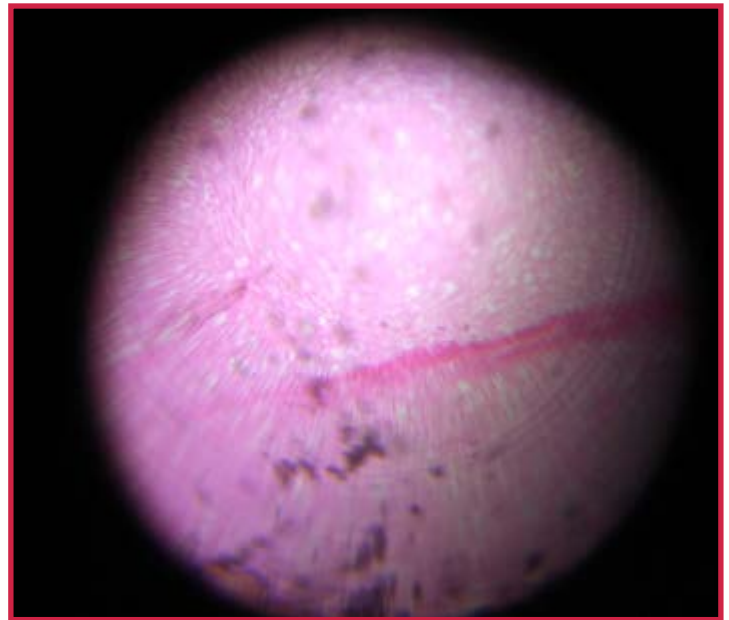
9. Uterus T. S.



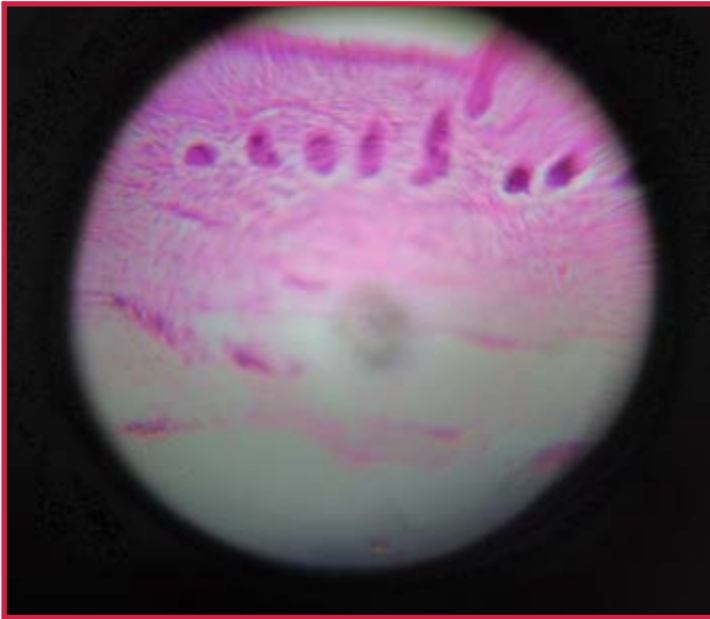
10. Cardiac Muscles T. S.



11. Kidney T.S.



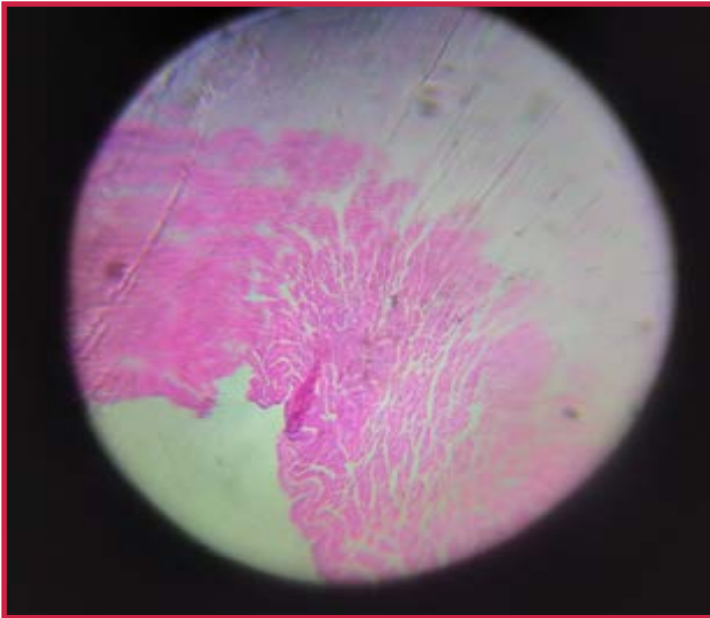
12. Spinal Cord T. S.



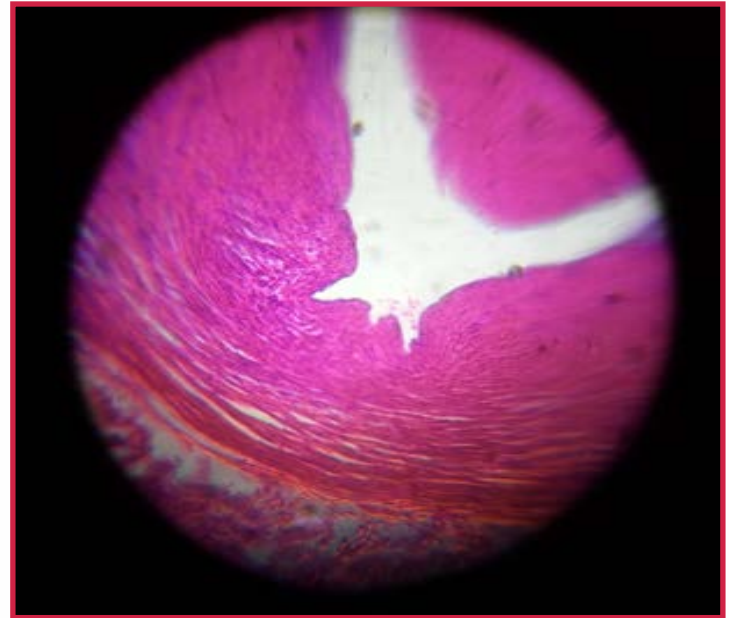
13. Skin T.S.



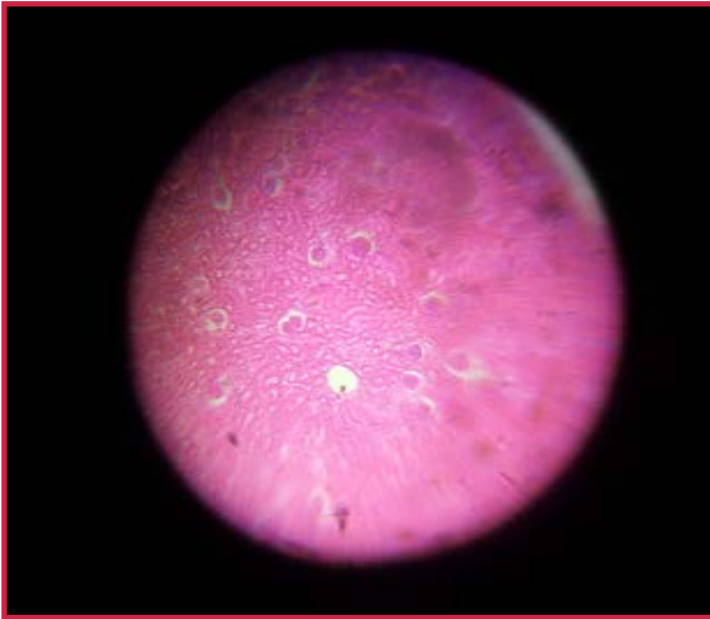
14. Colon (Rectum)T.S



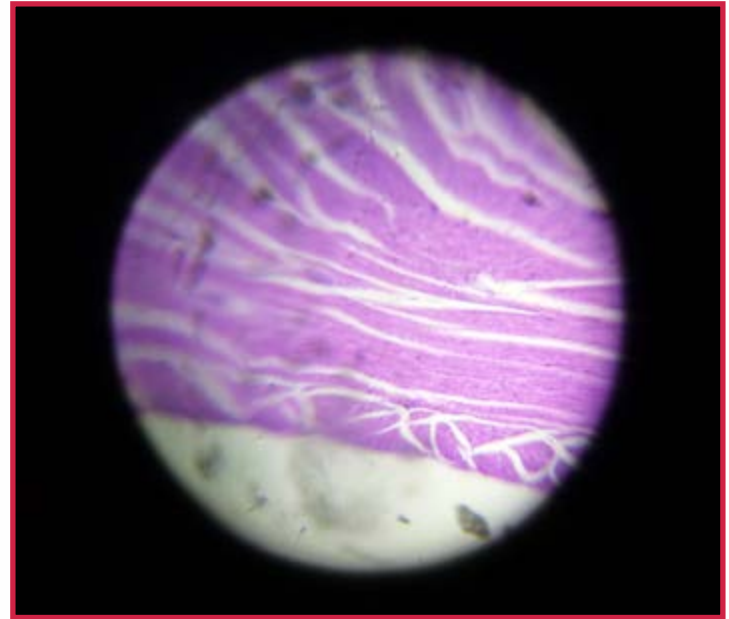
15. Aorta T.S.



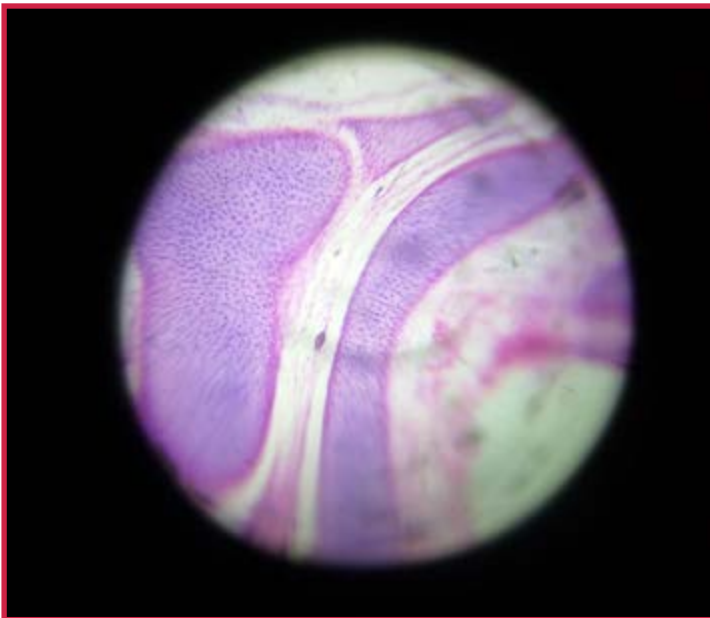
16. Artery T.S.



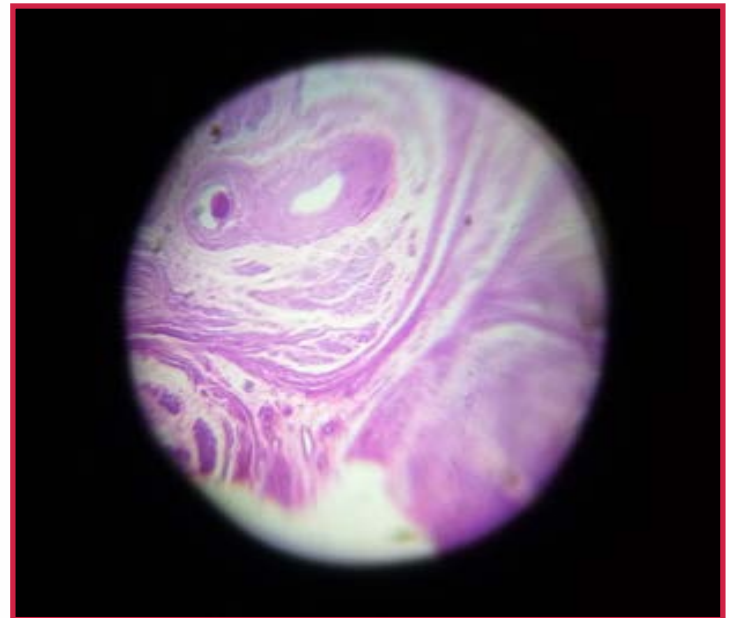
17. Cuboidal Epithelium



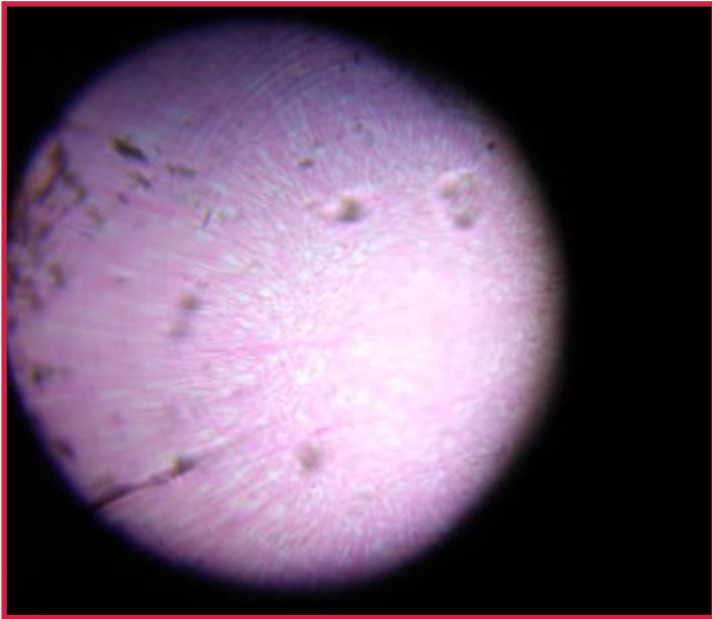
18. Heart T.S.



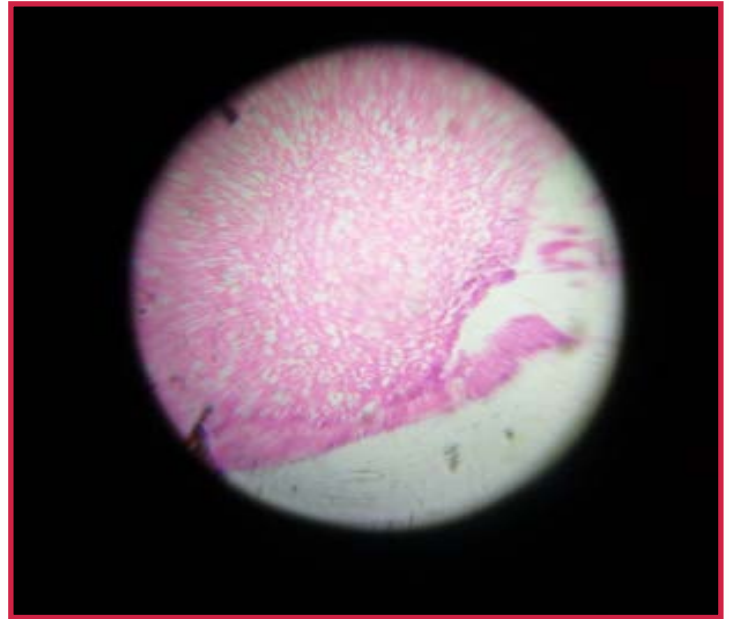
19. Hyaline Cartilage T.S.



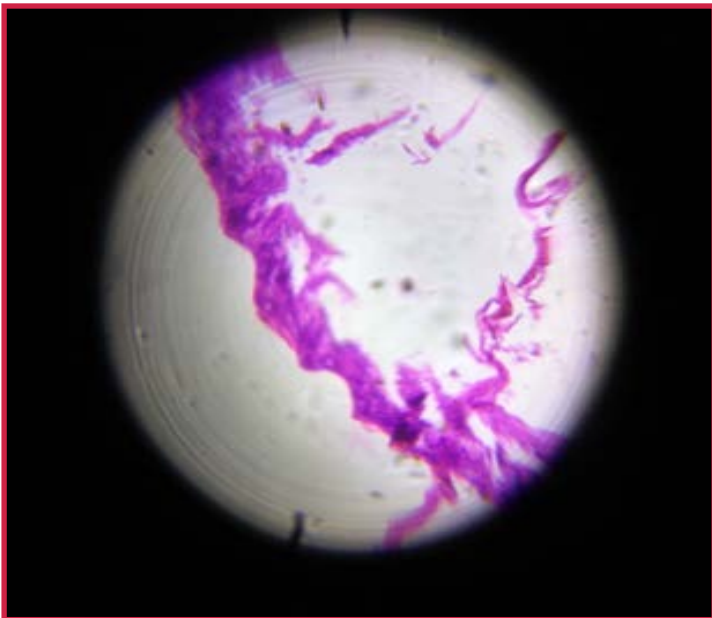
20. Smooth Muscles T.S.



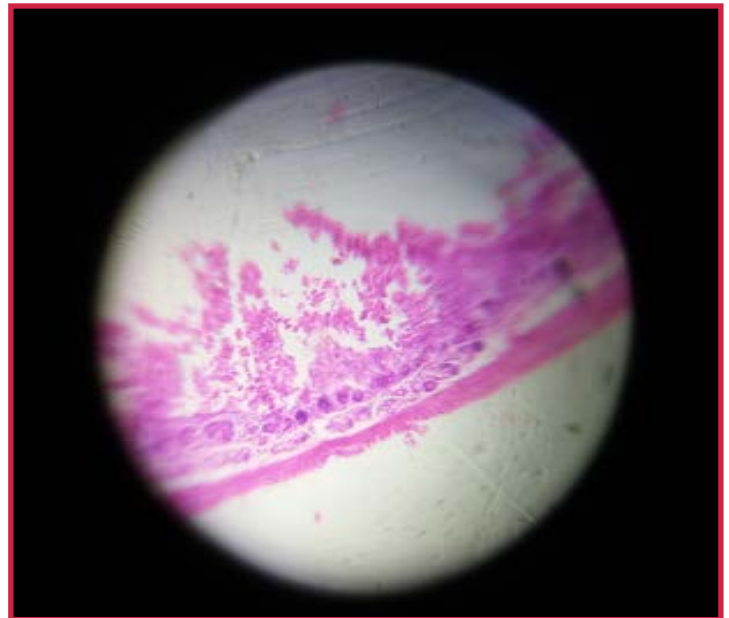
21. Spinal Cord T. S.



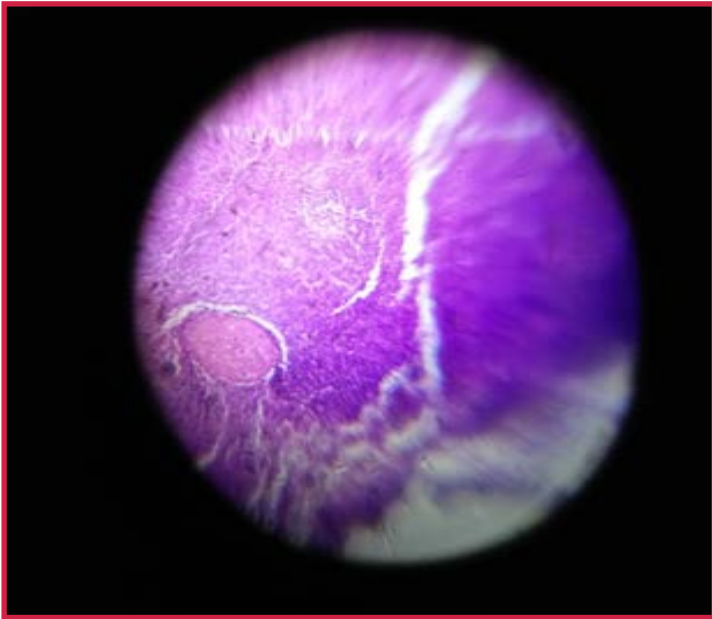
22. Nerve Cell T.S.



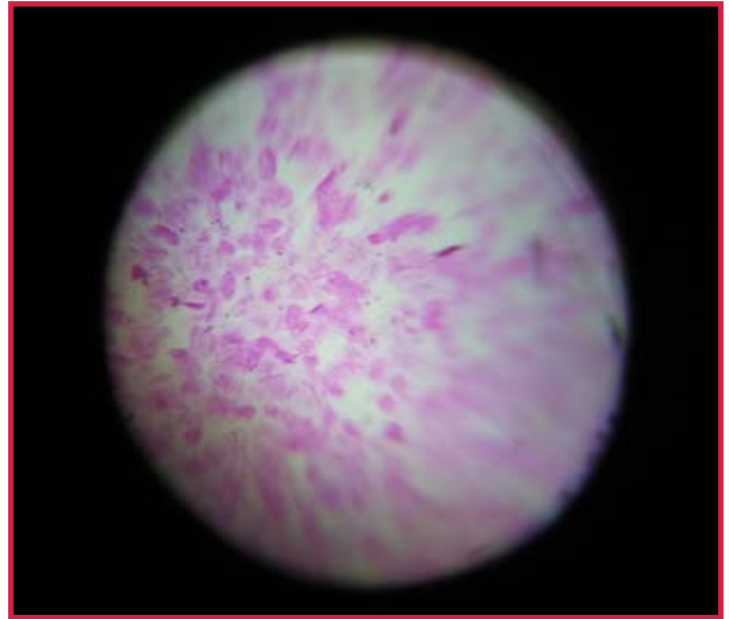
23. Large Intestine T. S



24. Small Intestine T.S.



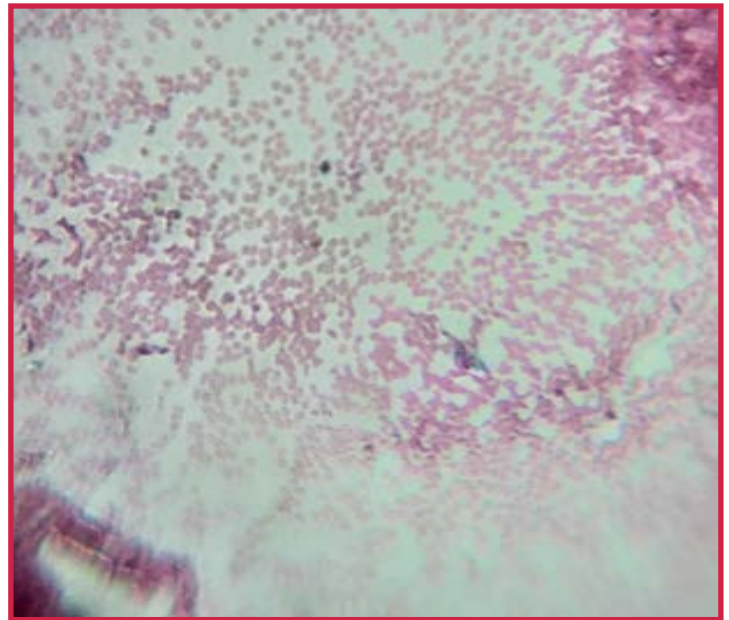
25. Spleen T.S.



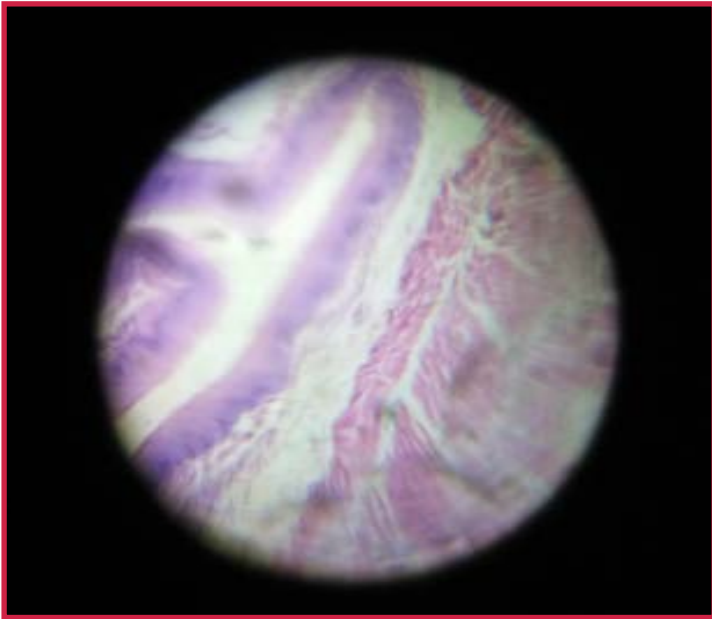
26. Squamous Epithelium



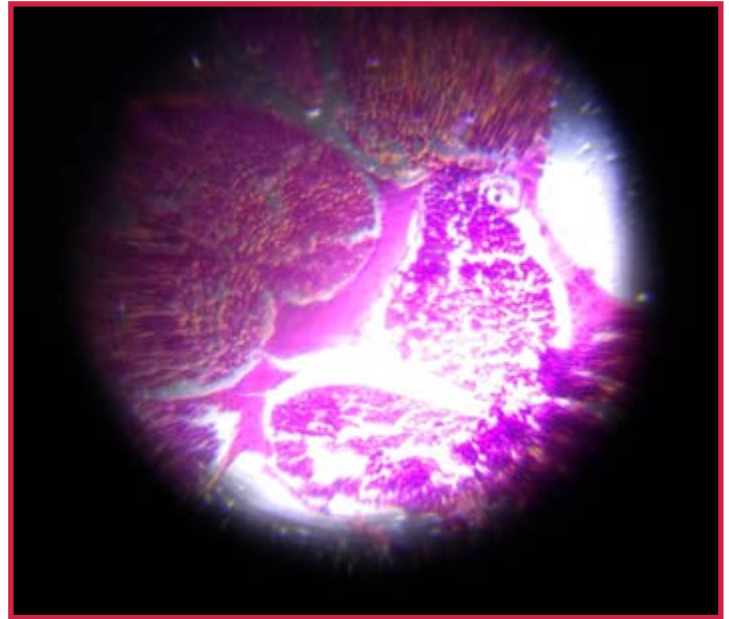
27. Stomach T.S.



28. Blood smear



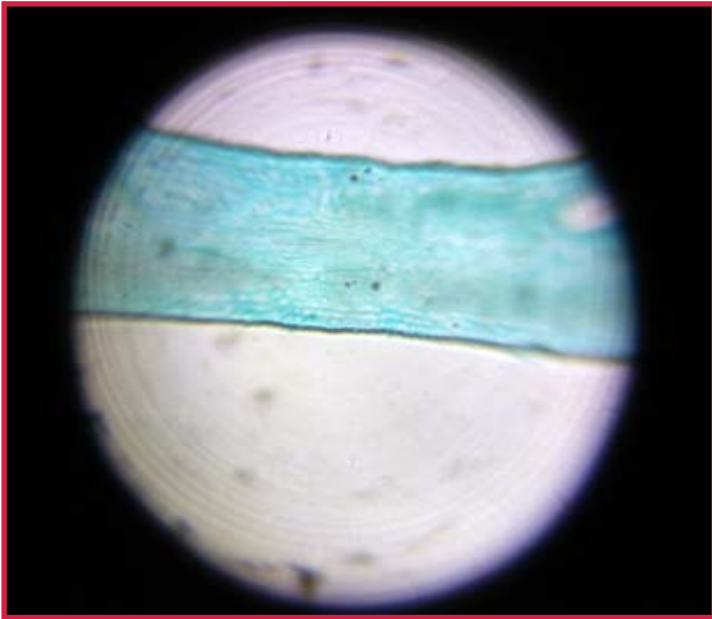
29. Mammal Oesophagus T.S.



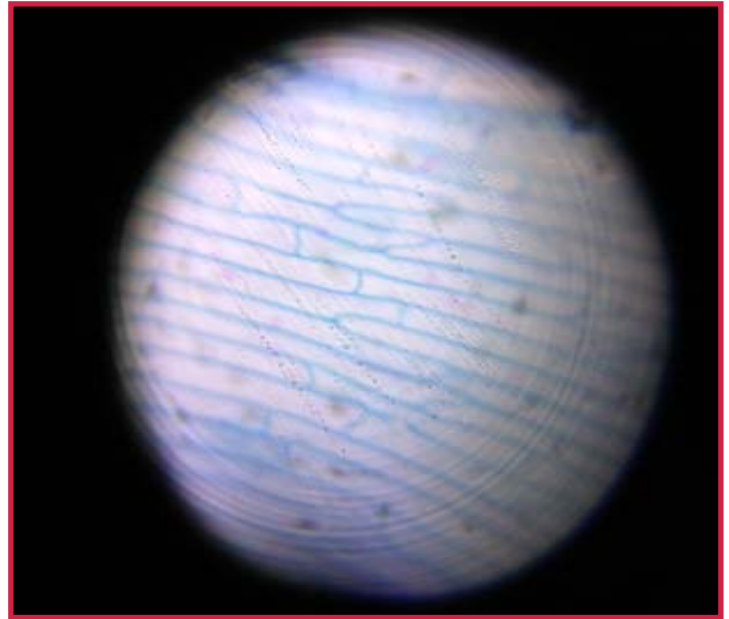
30. Ascaris Male T. S.

(E) Plant tissue

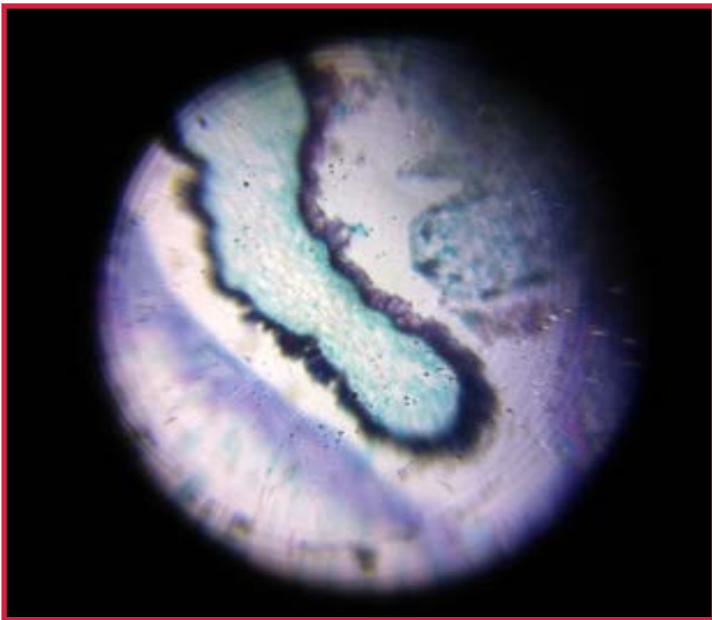
S. No.	Name of tissue	S. No.	Name of tissue
1	Dicot Leaf - T. S	19	Ranunculus stem T.S.
2	Onion Epidermis	20	Pollen grain W.M. Angiosperm
3	Ovule T. S	21	Azolla leaf T.S.
4	Root Nodule	22	Azolla leafs
5	Xylem Tissues - Angiosperm	23	Azolla root
6	Anther T. S. Angiosperm	24	Fern Rachis T.S.
7	Cycas Leaf T. S	25	Dicot stem T.S.
8	Cycas Stem T. S	26	Anther T.S. Angiosperm
9	Dicot Root T. S	27	Leaf stomata W.M. Angiosperm
10	Monocot leaf T. S	28	Lycopodium Cone T.S.
11	Monocot Root T. S	29	Lycopodium cone T.S.
12	Plant Cell w. m. Angiosperm	30	Monocot stem T.S.
13	Riccia sporophyte	31	Nostoc Algae
14	Tissue phloem T.S.	32	Tissue Collen chyma T.S.
15	Porella archegonia V.S.	33	Aquatic Moss
16	Tissue vascular	34	Chlorenchyma tissue Angiosperm
17	Stigmata of rice	35	Netrium spp
18	Pollen grain of rice		



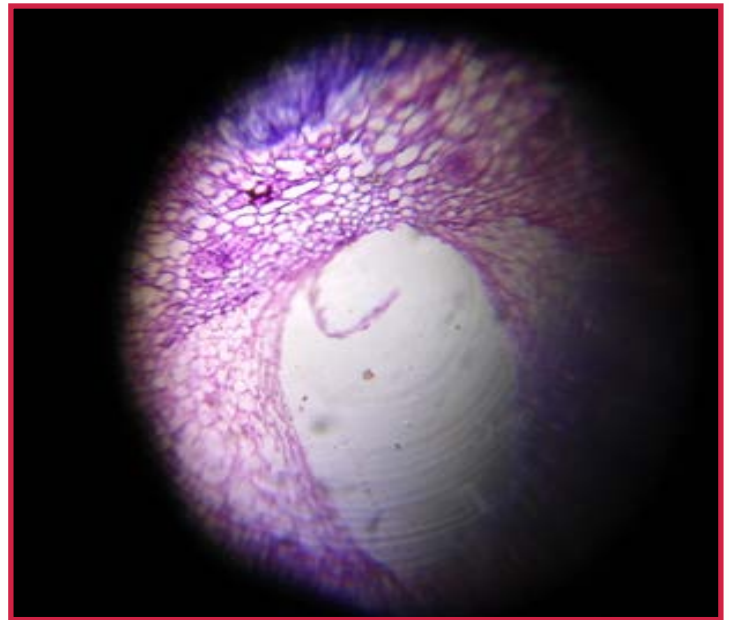
1. Dicot Leaf - T. S



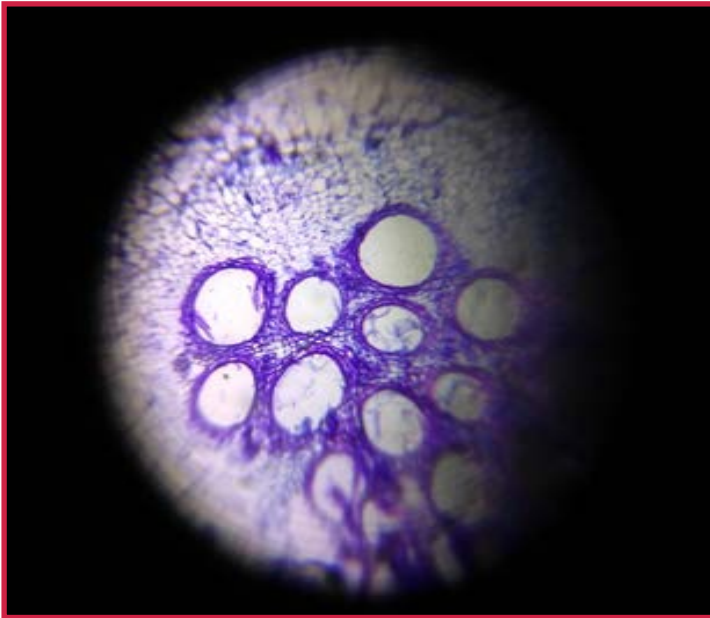
2. Onion Epidermis



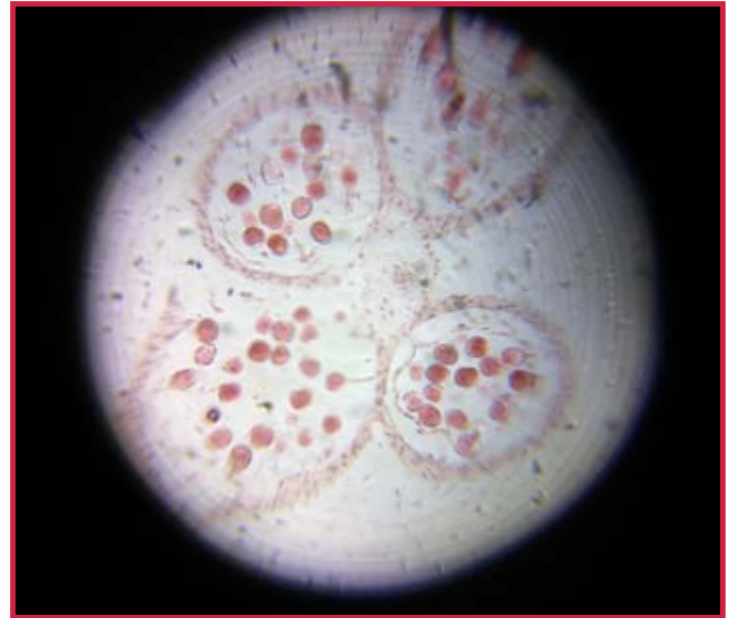
3. Ovule T. S



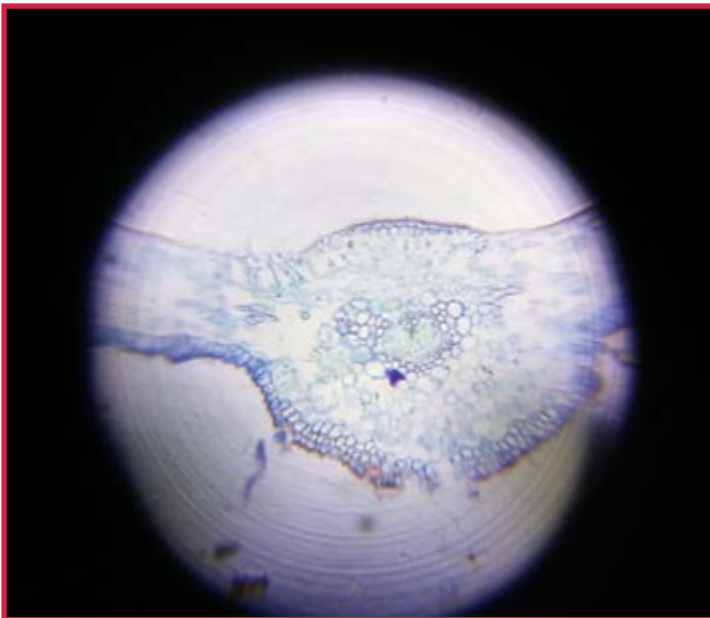
4. Root Nodule



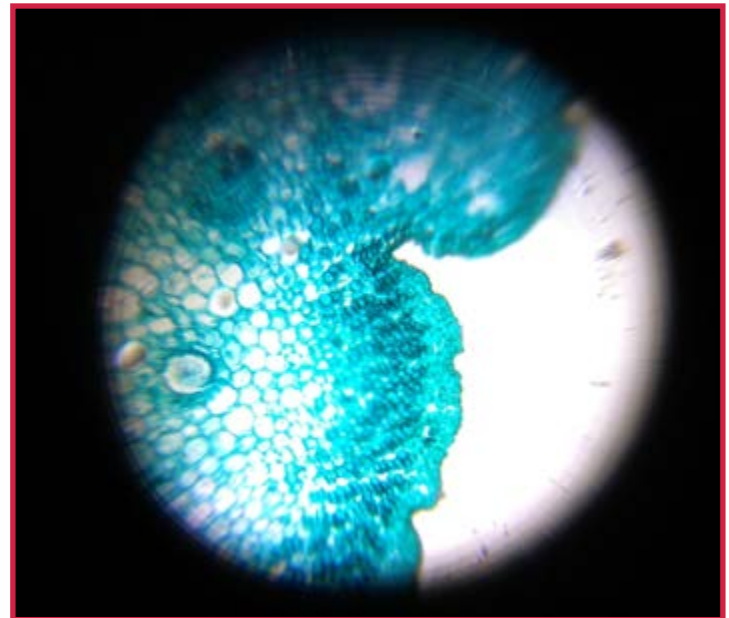
5. Xylem Tissues - Angiosperm



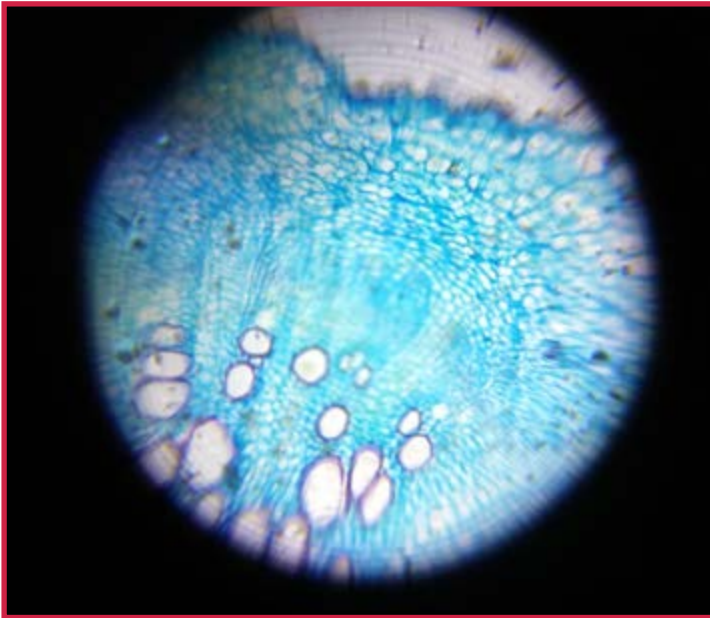
6. Anther T. S. Angiosperm



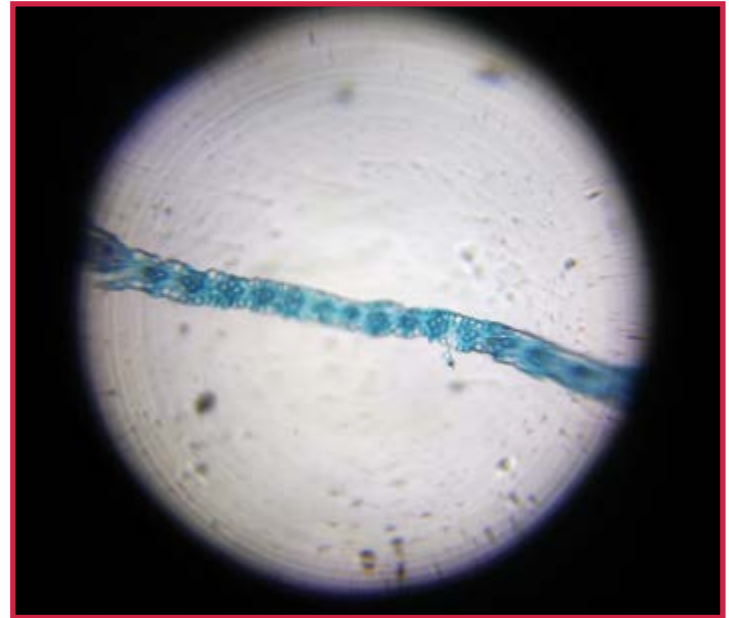
7. Cycas Leaf T. S



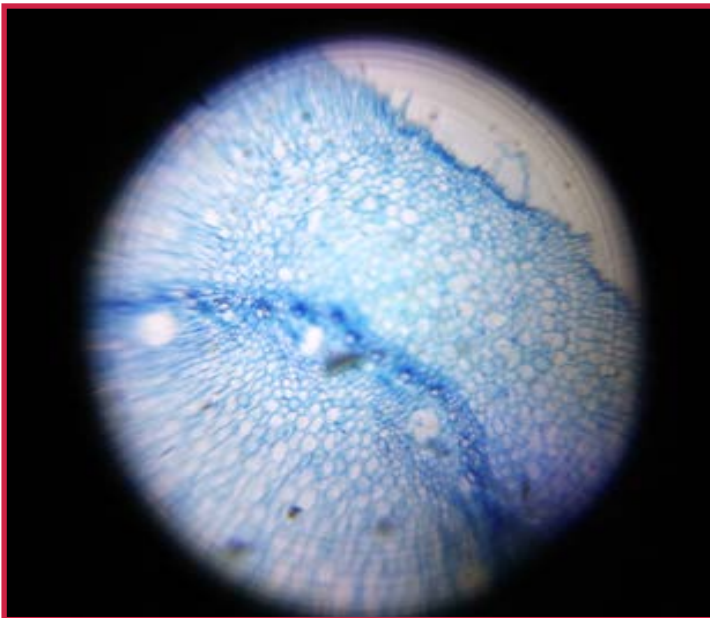
8. Cycas Stem T. S



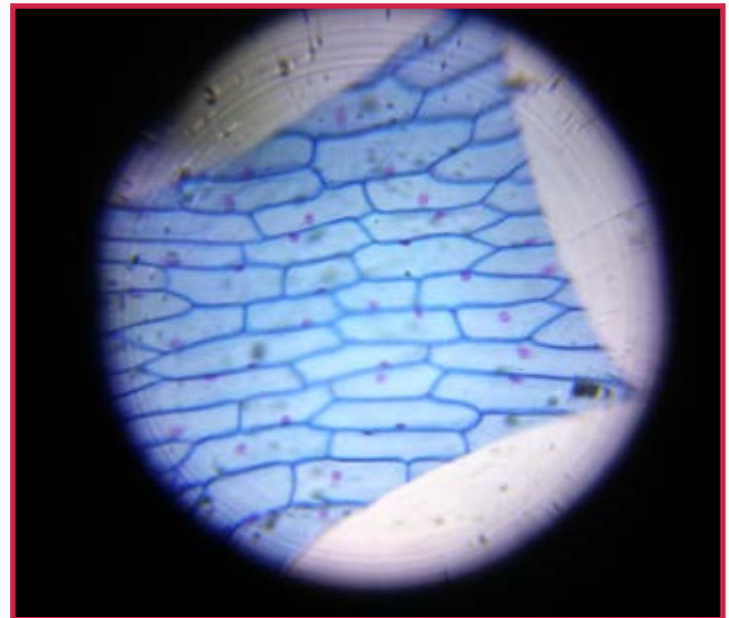
9. Dicot Root T. S



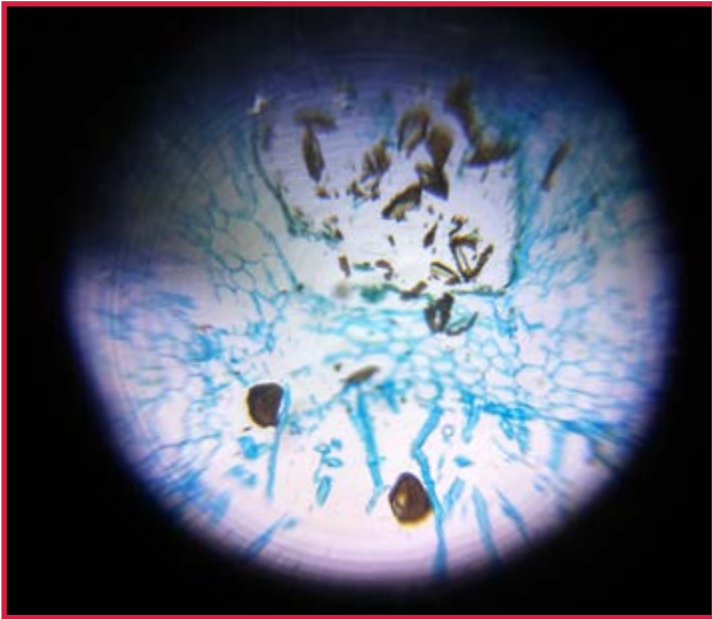
10. Monocot leaf T. S



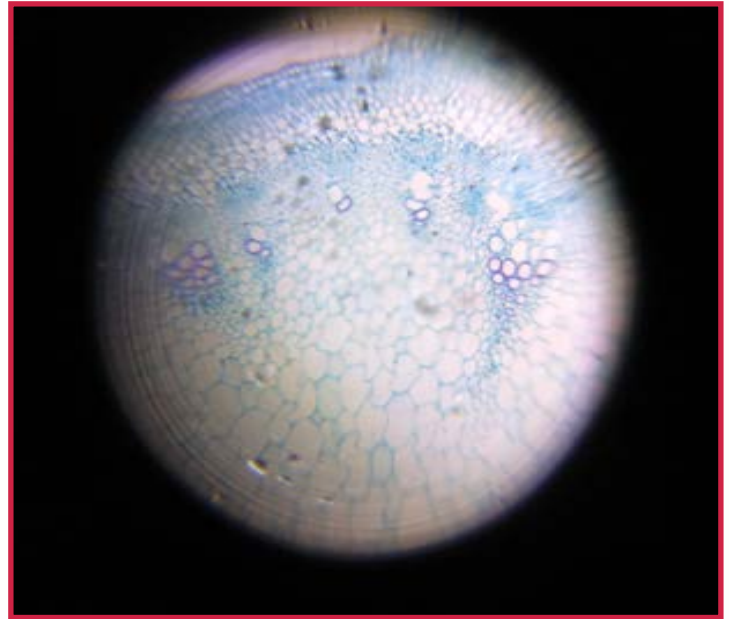
11. Monocot Root T. S



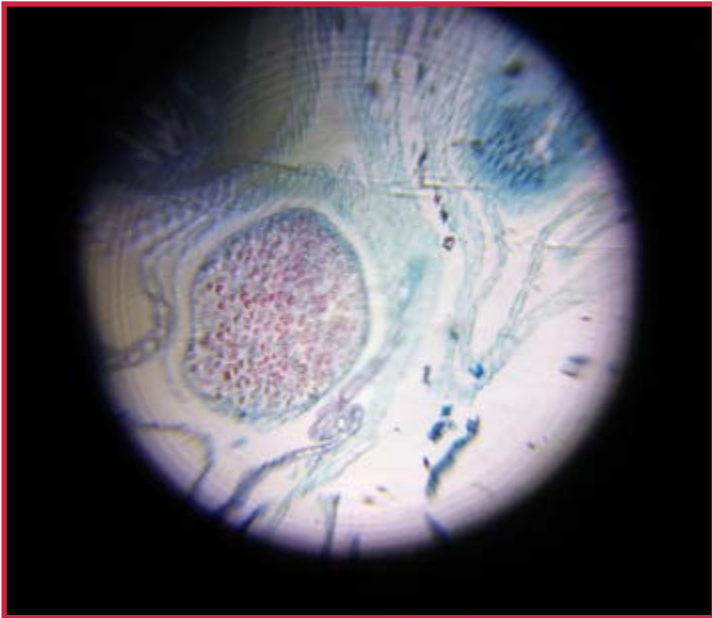
12. Plant Cell w. m. Angiosperm



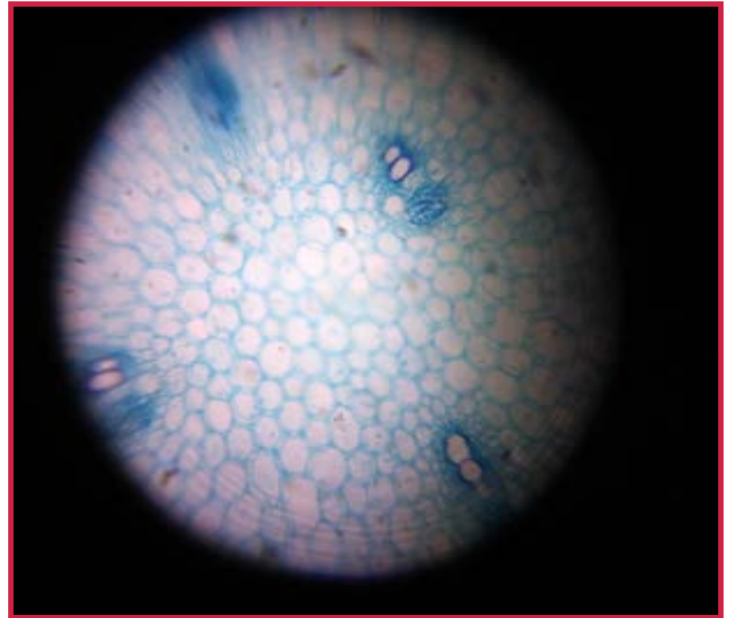
13. Riccia sporophyte



14. Tissue phloem T.S.



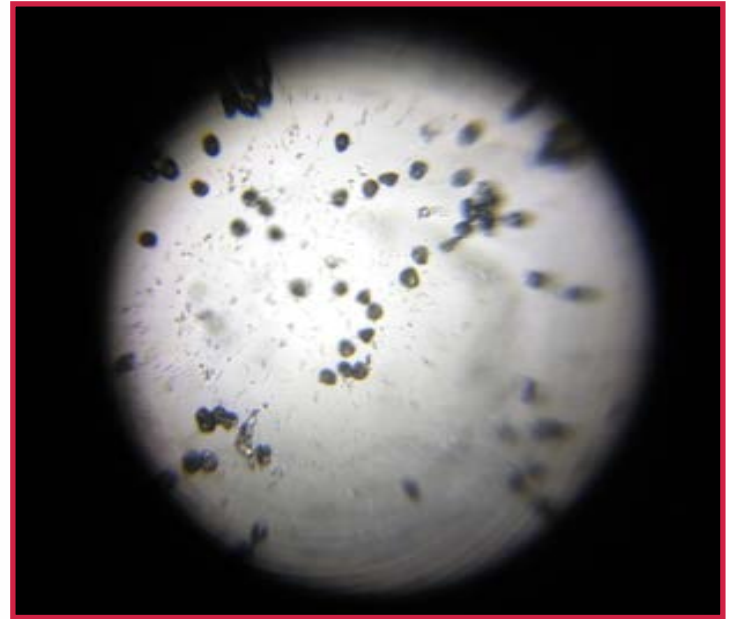
15. Porella archegonia V.S.



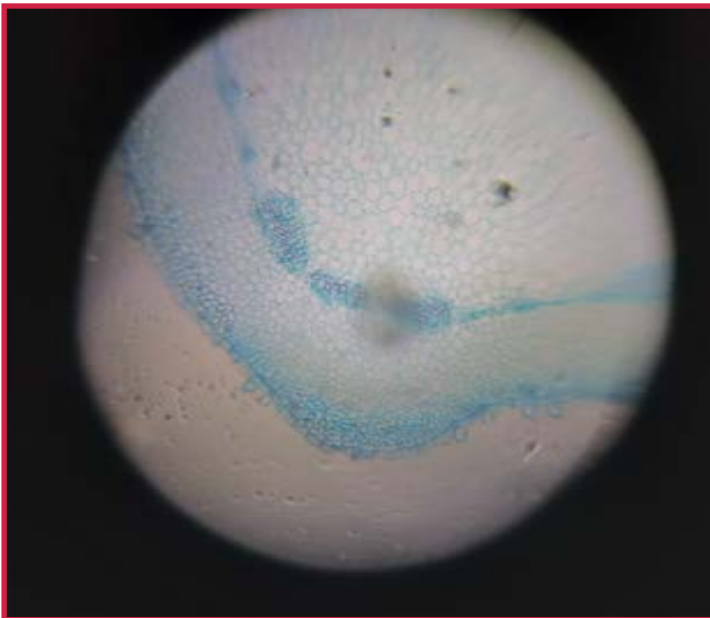
16. Tissue vascular



17. Stigmata of rice



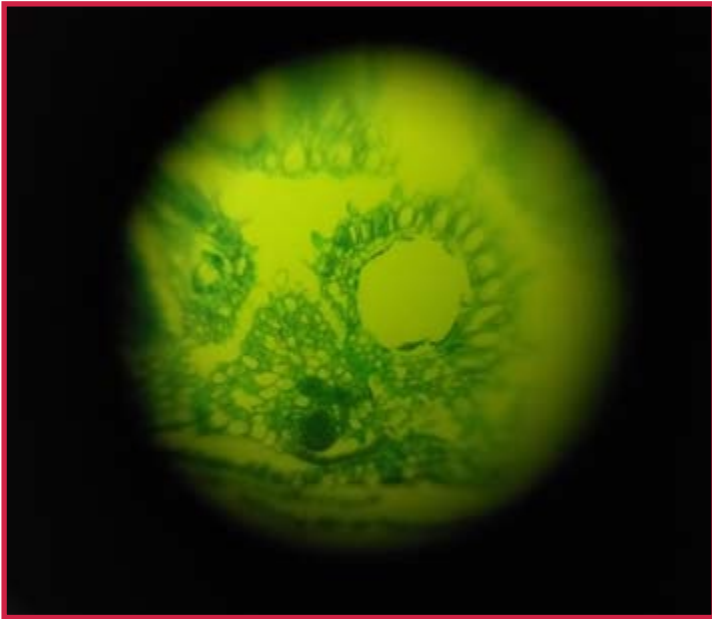
18. Pollen grain of rice



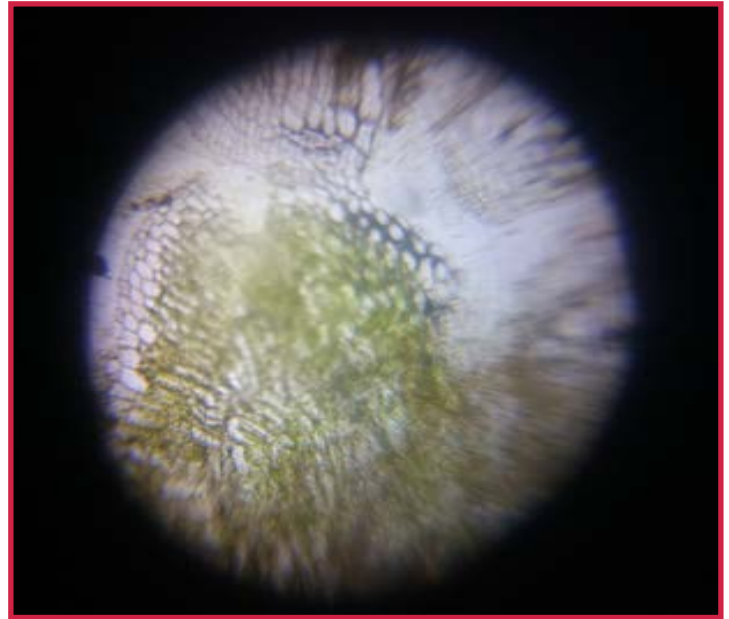
19. Ranunculus stem T.S.



20. Pollen grain W.M. Angiosperm



21. Azolla leaf T.S.



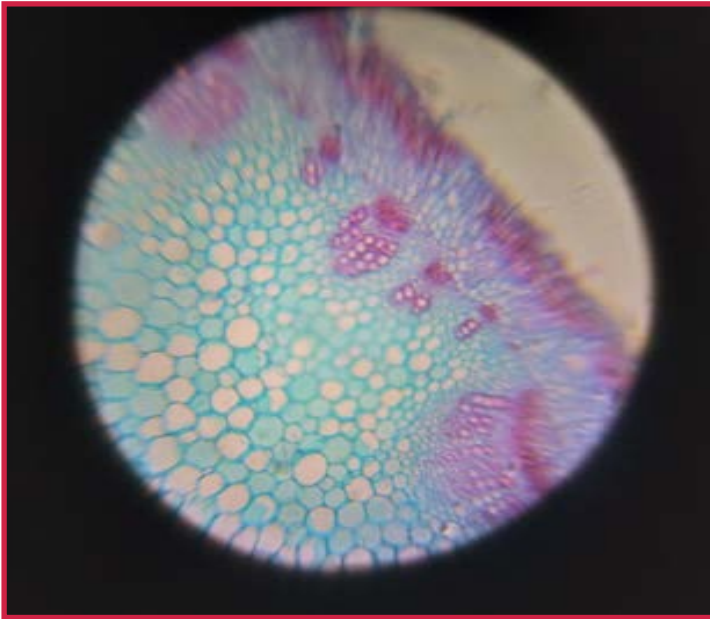
22. Azolla leaflets



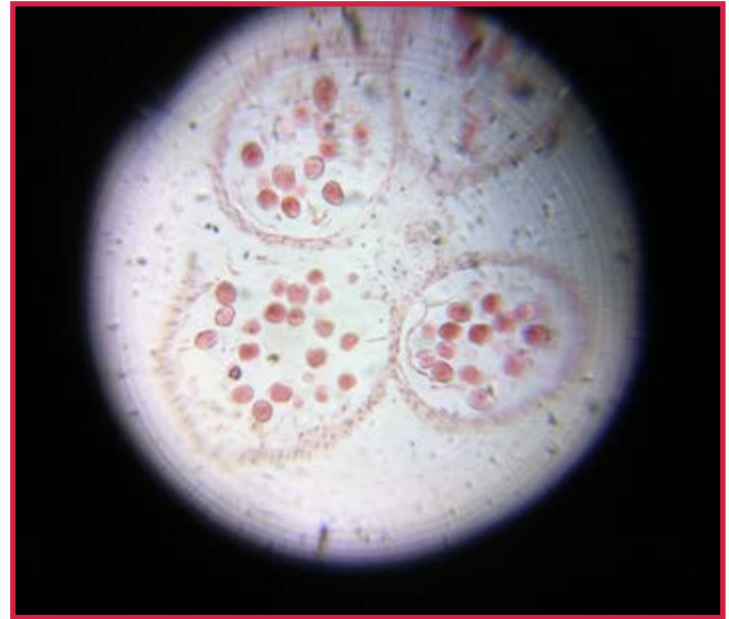
23. Azolla root



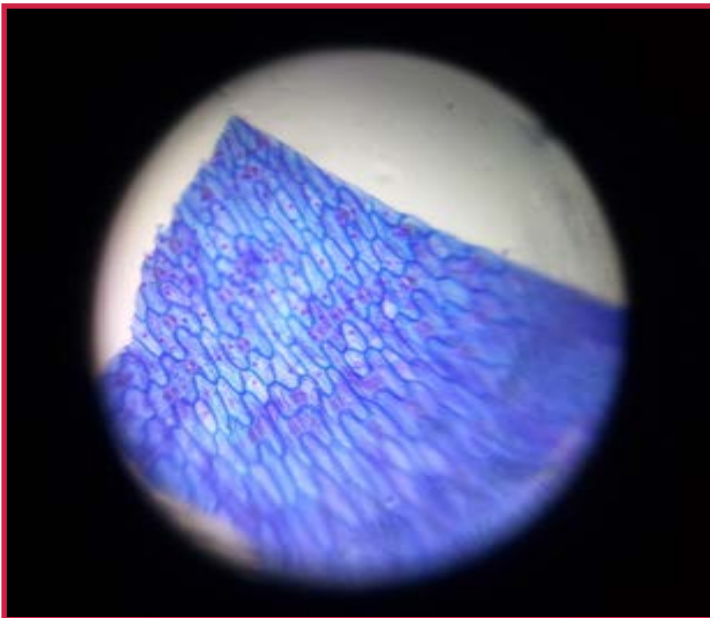
24. Fern Rachis T.S.



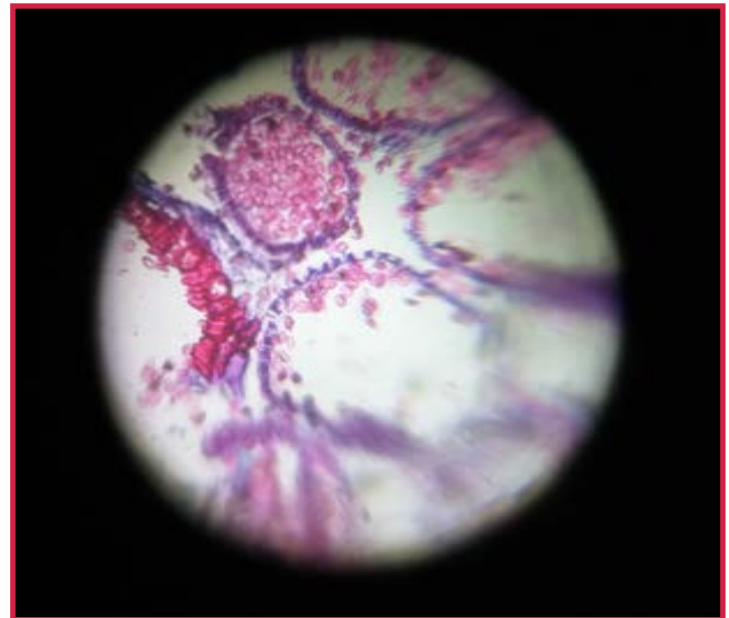
25. Dicot stem T.S.



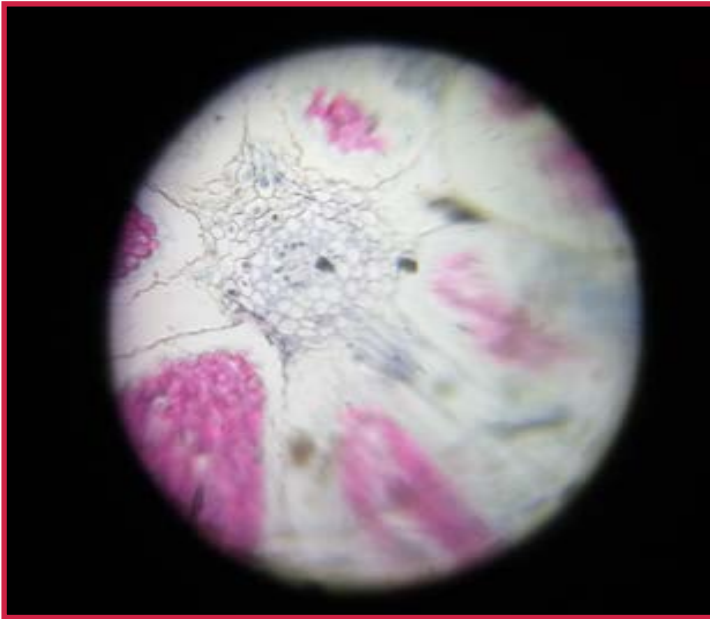
26. Anther T.S. Angiosperm



27. Leaf stomata W.M. Angiosperm



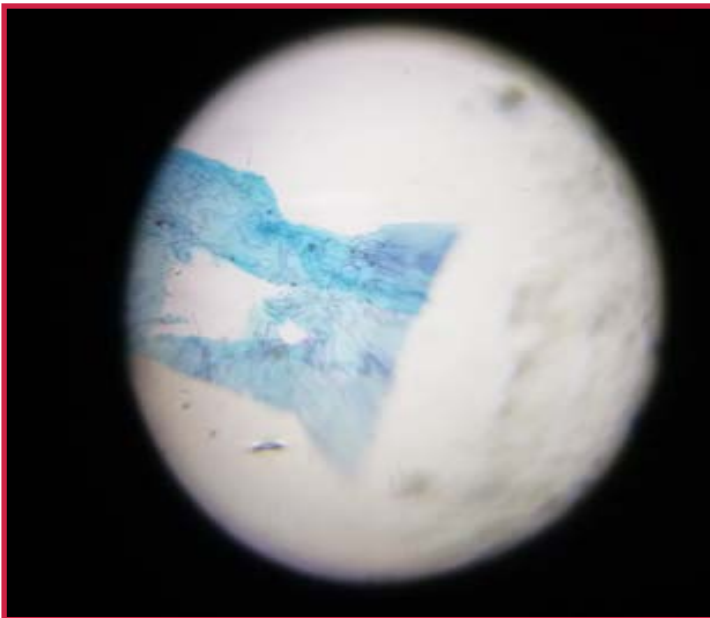
28. Lycopodium Cone T.S.



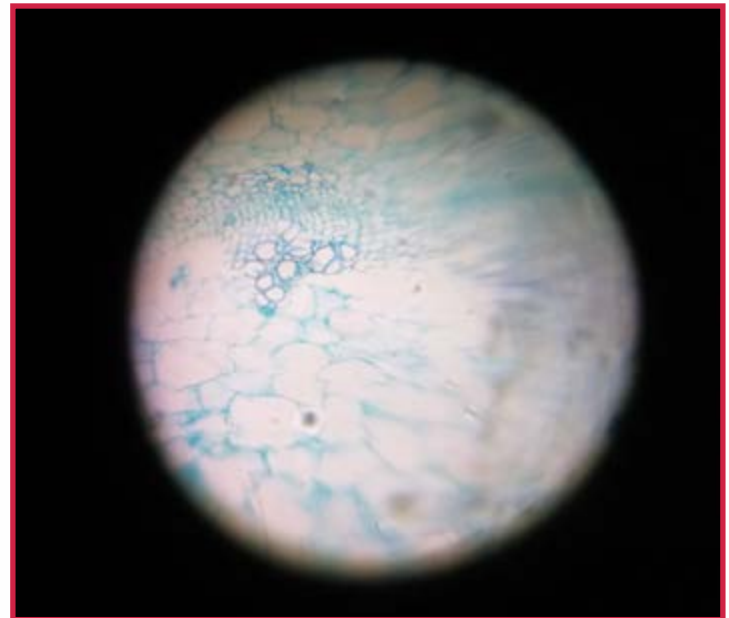
29. Lycopodium cone T.S.



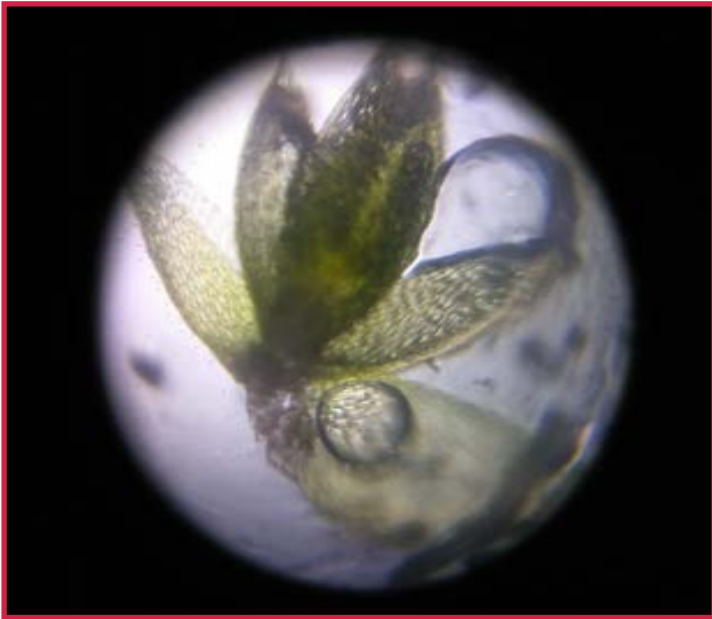
30. Monocot stem T.S.



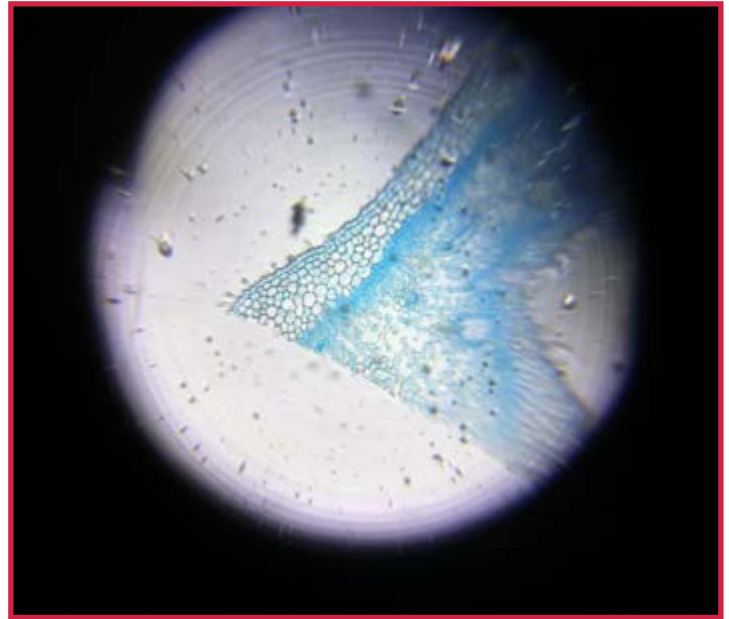
31. Nostoc Algae



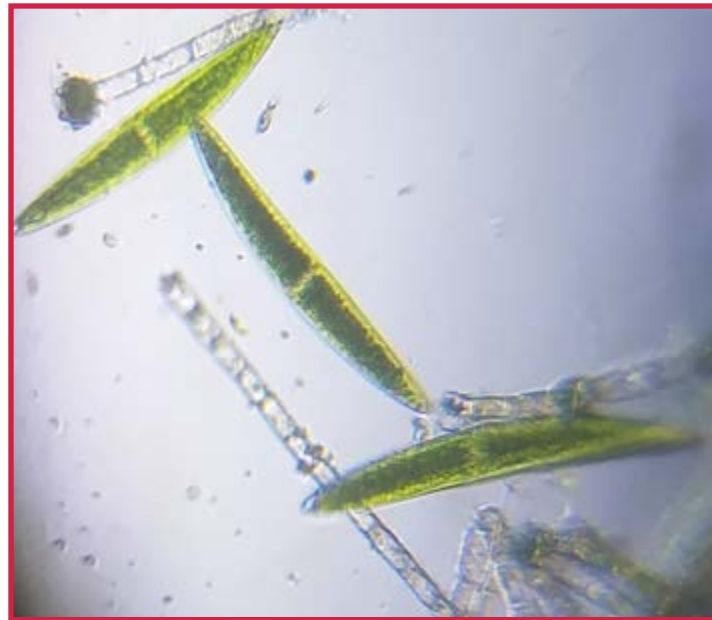
32. Tissue Collenchyma T.S.



33. Aquatic Moss



34. Chlorenchyma tissue Angiosperm



35. Nostoc spp

Significant achievement

Assessment of Frozen Semen Quality through Foldscope Microscopy- A Novel Application of Frugal Science to Reduce the Infertility Rate

For Artificial Insemination (AI) of cattle, semen evaluation is of paramount importance as the semen is used to inseminate a number of females. Further, there are more chances for semen straw contamination/low sperm counts due to various biotic, abiotic and storage factors. In field condition, evaluation of semen quality in straw before AI of cattle (mass motility and count) is a bottle neck due to lack of infrastructure. The poor quality semen straw used in AI resulting in low conception rate and repeat breeding cases arise with cost and time constraints. To overcome this barrier, We have used Foldscope to test the semen quality in straw (mass motility) before AI; the observation was very fruitful and we have seen the mass motility of spermatozoa. Further, we have received the guidance from Dr Manu Prakash is that the counting of live spermatozoa through *ImageJ* software will help to determine the quality of semen before AI.



Research team: Dr. Mamta Choudhary and Dr. P. Mooventhan

Capacity Building Programmes

Awareness and capacity-building programs on the application of foldscope microscope and diagnosis of plant pathogenic disease

S. No.	Activities	No. of Events	Village/ Institute	Male Farmers	Female Farmers	Students	Extension Functionaries	Total Participants
1.	Demonstration	18	17	303	180	37	10	530
2.	Training	23	19	186	71	450	83	790
3.	Workshop	1	1	20	130	0	0	150
Total		42	37	509	381	487	93	1470



Demonstration to Rural Farmers and Youth







Demonstration to Women Farmers and SHGs







Demonstration to College Students







Demonstration to School Students







Demonstration to State Extension Functionaries





Demonstration to Delegates of ICAR-NIBSM





Major Achievements of Foldscope Initiatives

- ❖ Explored the socio-economic status, knowledge level of tribal farmers and college students on zoonotic diseases, plant disease, diagnosis, and tribal farmers' attitude/perception towards foldscope microscopy.
- ❖ Total 407 samples were collected from different sources to screen the zoonotic, plant disease and other relevant pathogens from the farmer's fields, research centers, and agricultural universities at different locations in Chhattisgarh.
- ❖ Total 171 samples were diagnosed in-situ/ex-situ through the help of Foldscope microscopy.
- ❖ Mostly foliar fungal diseases were in-situ diagnostic viz. *Ustilaginoidea virens*, *Magnaporthe grisea*, *Alternaria* spp, *Cercospora* spp, *Erysiphe* spp, *Golovinomyces* spp, *Leveillula taurica*, *Cephaleuros virescens*, *Penicillium digitatum*, *Botrytis* spp, *Oidium erysiphoides*, *Albugo bliti*, *Puccinia* spp, *Rhizopus* spp and *Ustilago tritici*.
- ❖ Under Ex situ diagnosis the clinical samples were processed and Fungi (*Aspergillus fumigatus*, *Penicillium* spp, and *Rhizopus* spp.), pathogenic yeast (*Candida* spp.), Bacteria (*E. coli*, *Pseudomonas* spp., *Aeromonas* spp. and *Proteus* spp.) were isolated and observed through foldscope microscopy.
- ❖ In situ viability test of bioagent viz. *Trichoderma* spp and *Pacelomyces* spp has successfully observed under Foldscope.
- ❖ In Foldscope project we have covered more than 56 organisms/tissue such as fungi, bacteria, yeast, algae pathogens, zoonotic pathogen, histology and plant tissue.
- ❖ As a field application, foldscope was identified as a novel tool to test the semen quality in straw provided for Artificial Insemination (AI) of cattle. This intervention has the significant scope to increase cattle's conception rate, which will pave the way for successfully grading indigenous cattle.

- ❖ As a part of the capacity-building initiative 42 events such as training, demonstration, workshop and awareness campaign on the in-situ diagnosis of plant pathogenic fungi and zoonotic disease through Foldscope microscope to farmers, rural youth, college students, agriculture extension officers, horticulture extension officers, veterinary officers and teaching faculty of the institute.
- ❖ Total 1470 participants benefitted from this initiative, in which 509 are male farmers, 381 are female farmers, 487 are collage and school students and 93 are extension functionaries.
- ❖ Thirty-one rural youths as well as students are trained at the field level to demonstrate the foldscope microscopy to needy people.
- ❖ **Area Covered:** All capacity building programme conducted in eight district of Chhattisgarh state viz. Janjgir-Champa, Raigarh, Balodabazar-Bhantapara, Rajnandgaon, Mohala Manpur Ambagarh Chowki, Dhamtari, Durg and Raipur.
- ❖ Samples were collected from fifteen district of Chhattisgarh state viz. Surguja, Koriya, Jashpur, Korba, Raigarh, Sakti, Bilaspur, Mungeli, Kabirdham, Bemetara, Mahasamund, Balodabazar-Bhatapara, Kanker, Baster and Raipur.
- ❖ Training and demonstration programme has done in various agricultural and educational institute of Chhattisgarh state.
- ❖ In the online platform, total 297 (images/videos) were published in the MICROCOSMOS (<https://microcosmos.foldscope.com/>) Foldscope Community under both projects.
- ❖ Diagnosis of crop diseases at the initial level, it's very helpful to minimize the crop yield losses of farmers and also reduces the input cost, foldscope microscopy has proved the best solution for this.
- ❖ AI-powered Fungus Diagnostic Model using Foldscope Microscopy is in progress with Centre for Development of Advanced Computing (C-DAC), Chennai, Ministry of Electronics and Information Technology (MeitY), Gol.

Visit of Dr. Manu Prakash (Inventor of Foldscope Microscope) to Raipur (C.G.)



Acknowledgment and Thanks to



Reaching the Unreached...



सत्यमेव जयते

DEPARTMENT OF BIOTECHNOLOGY
GOVERNMENT OF INDIA



सत्यमेव जयते

DEPARTMENT OF SCIENCE AND TECHNOLOGY
GOVERNMENT OF INDIA

