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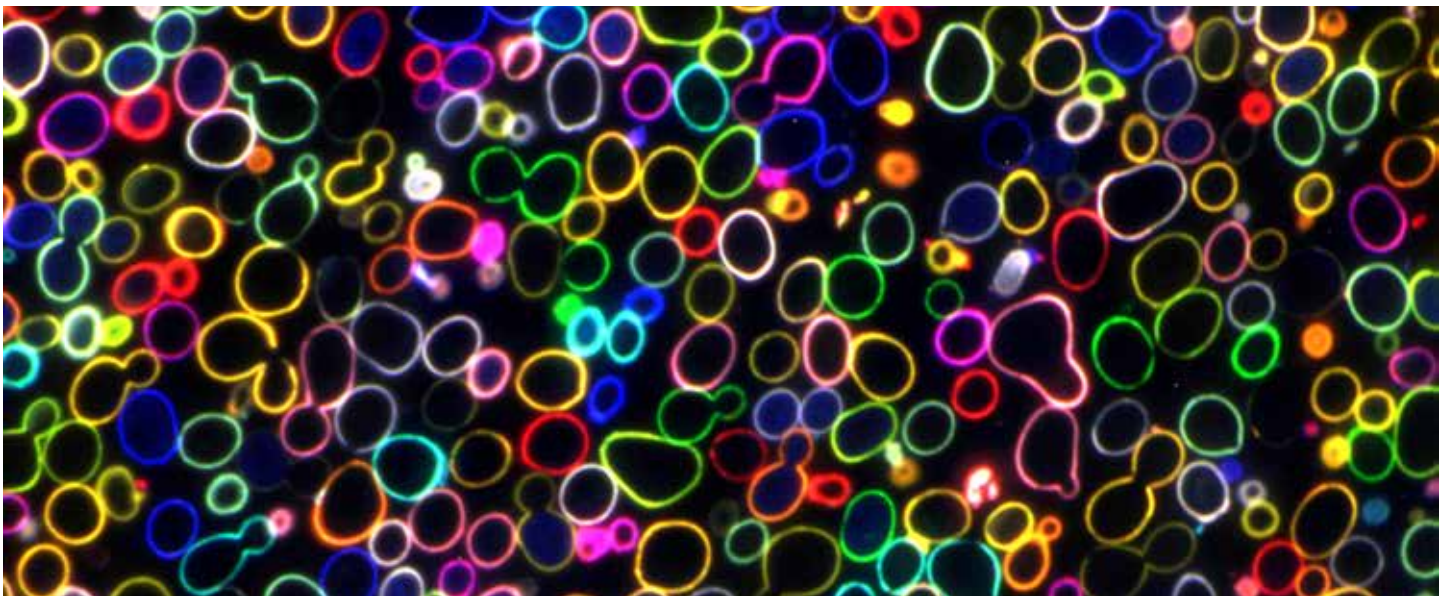


Colours in the dark: fluorescence microscopy for the classroom

Hariharan Arevalagam, Shweta Gaikwad

Microscope in Action is a hands-on educational resource for teaching fluorescence microscopy in the classroom and beyond.

The development of fluorescence microscopy in the early 20th century marked the beginning of a new era in the field of microscopy and opened the door to a plethora of new discoveries. It enabled scientists to study the intracellular distribution of molecules like specific proteins and their interactions by using different fluorescent dyes and tags. It also made it possible to identify specific cell types in tissues and probe cellular dynamics, such as cell division, in living cells and organisms. As a result, the fluorescence microscope is an indispensable tool for biologists. Despite its prevalence in life-science research, fluorescence is a neglected topic in secondary-school curricula. Furthermore, most fluorescence microscopes on the market are inaccessible to many schools. The European Learning Laboratory for the Life Sciences (ELLS), the education team of the European Molecular Biology Laboratory (EMBL), in collaboration with researchers from EMBL and EMBLEM Technology Transfer GmbH, decided to address this problem and developed the Fluorescence Learning Microscope as part of the comprehensive educational resource, Microscope in Action (MiA).

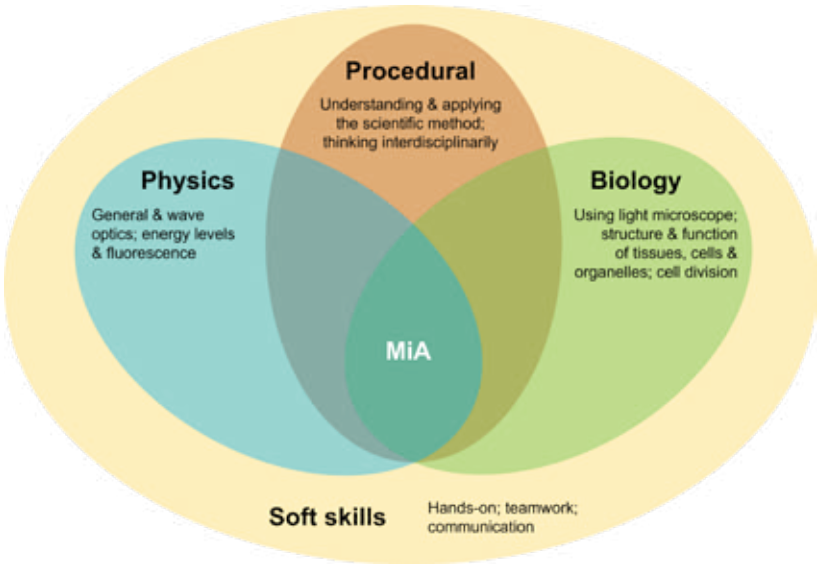
The Microscope in Action educational resource

Microscope in Action – bringing fluorescence to students

MiA is an educational resource targeted at secondary-school students. It contains a DIY fluorescence microscope called the Fluorescence Learning Microscope. Based on commercially available components, it is one of the most affordable research-grade fluorescence microscopes available. By employing pedagogical tools such as hands-on learning and collaborative problem solving, students can develop content knowledge in biology and physics while also increasing their competencies in procedural knowledge, such as applying the scientific method and thinking in an interdisciplinary manner. Students also improve key soft skills including teamwork and communication skills. Between 2018 and 2020, this newly developed resource was pilot tested in a series of classroom workshops.

Modular workshop structure

The MiA workshops are presented as three key modules: the assembly module, the sample preparation module, and the imaging module.



Scheme highlighting the content knowledge and competencies in the subjects of biology and physics, procedural knowledge, and non-subject-related "soft" skills of the MiA resource.
Image obtained from Ref [1].

The individual components of the Fluorescent Learning Microscope
© Massimo Del Prete

In the assembly module, the students put the fluorescence microscope together. The process of assembling the microscope helps them gain a deeper understanding of each individual component and its function. Once the microscope is assembled, the sample preparation module trains the students to prepare biological samples for imaging. This module includes various exercises which cover the basics of using a micropipette, preparing dilutions, mounting different materials like pollen or carrot sections on slides for observation, and the concept of staining.

In the imaging module, students learn to save, process, and analyze images they have acquired. This module includes exercises on calibrating the camera, experimenting with filters, and measuring the intensity of fluorescence in samples by using open-source image-processing programmes.

Samples being prepared for imaging
© EMBL

Learning, teaching, and facilitation materials

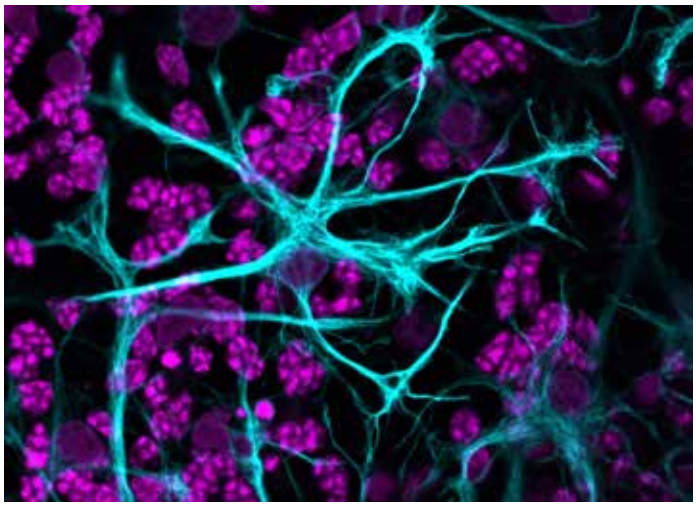
A young learner using the Fluorescence Learning Microscope under the supervision of a facilitator
© EMBL

MiA is designed to be flexible; teachers can use the various resources in whichever way fits their individual learning goals and caters best to the needs of their students. The handbooks include ready-to-use manuals, worksheets for classroom use, answer keys, extra assignments, and further reading sections. Additionally, teachers can utilize a ready-to-use slide deck to familiarize both themselves and their students with the basic concepts of fluorescence microscopy. Video guides provide support for microscope assembly and sample preparation and recorded talks by EMBL scientists can be used to introduce the topic in class and give insights into authentic life-science research.

To help teachers organise a MiA workshop in their classrooms, sample schedules are provided which range from one-day workshops to multi-lesson plans. In addition, the handbooks also offer recommendations on how to facilitate these sessions in groups to ensure that all students get the chance to partake in each and every aspect of the learning experience, from assembly to imaging.

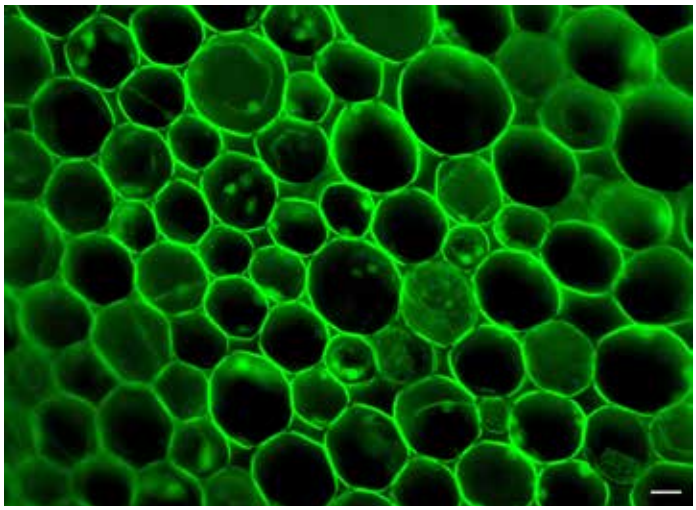
Student and teacher evaluations

Assessments and feedback of the learning experience showed that students displayed a marked improvement in practical and experimental skills and increased their learning motivation. Written in-class exams further indicated a strong grasp of the topics covered in the MiA sessions.



Confocal microscopy image of astrocytes in a culture of rat retinal cells. The filament protein GFAP in shown in cyan and the cell nuclei in magenta.

Image by Sandra Correia, from the 2018 EMBL Photoclub calendar.



Convallaria rhizome stained with acridine orange and visualized with the EMBL Fluorescence Learning Microscope

Get in touch for your own MiA experience

MiA is a versatile educational resource with curriculum links to physics and biology and connections to chemistry, technology, and art. It can be used in formal and informal learning environments with students from the age of 14. We offer a free-of-charge lease service through which you can bring the MiA experience to your classroom. This service is currently available to educators in Germany and is expected to expand to other countries soon. Further information about the resource and the lease service can be found on our webpage, https://www.embl.org/ells/microscope-in-action/.

If you would like to find out more about the science behind fluorescence microscopy, stay tuned for the upcoming *Understand* article brought to you by EMBL. «

References

[1] Paci G. et al (2021) Microscope in Action: An Interdisciplinary Fluorescence Microscopy Hands-on Resource for Schools. *The Biophysicist* **2** : 55–73. doi: 10.35459/tbp.2020.000171

[2] Microscope in Action: https://www.embl.org/ells/microscope-in-action/

Resources

Articles on optics, fluorescence microscopy, and GFP

- The GFP as the molecule of the month on the PDB Educational portal.
- Read about the discovery and potential applications of GFP: Furtado S (2009) Painting life green: GFP. *Science in School* **12**: 19–23.
- Hodge R (2006) A bright future for light microscopy. *Science in School* **1**: 22–25.
- An introduction to optics on the *Encyclopaedia Britannica*.

Articles on applications of fluorescence microscopy

- Read about the scientists who followed the development of a digital embryo via fluorescent microscopy: Furtado S (2010) Watching it grow: developing a digital embryo. *Science in School* 15: 18-22.

- This experiment followed meiosis under the microscope: Furtado S (2012) Sloppy fishing: why meiosis goes wrong. *Science in School* **25**: 13–17.
- Read an article in *New Scientist* about the use of GFP to study zebrafish neurons.
- A Science News article on the first biolaser.
- Find out about Fluorescence In Situ Hybridization (FISH) which uses fluorescence to locate the position of specific DNA sequences or chromosomes in this article on *Nature Education*.

Videos

- Watch the EMBL Insight Lecture 2015, on the imaging of cell division.
- Watch a video on the history of the GFP discovery and how it revolutionized bioimaging.
- A whiteboard video on some of the GFP uses and its mechanism.
- Find out more about GFP structure and other fluorescent proteins.
- Watch a video about STED microscopy, that enabled researchers to see beyond the nanoworld.
- Watch this TEDMED talk on the use of molecular markers in surgery.
- Watch a TED talk on the use of GFP to look inside the brain.
- Watch an introductory video on fluorescence microscopy.

AUTHOR BIOGRAPHY

Hariharan Arevalagam is a science communicator who uses his writing to entertain and inspire. He is currently a trainee in EMBL's science education department, ELLS, where he hopes to develop his skills further and help bring science closer to everyone.
Shweta Gaikwad is a biologist at heart and science educator in the real world, connecting research and researchers with people because having fun with science isn't just for scientists! She is currently in Germany working in EMBL's science education department, ELLS.

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