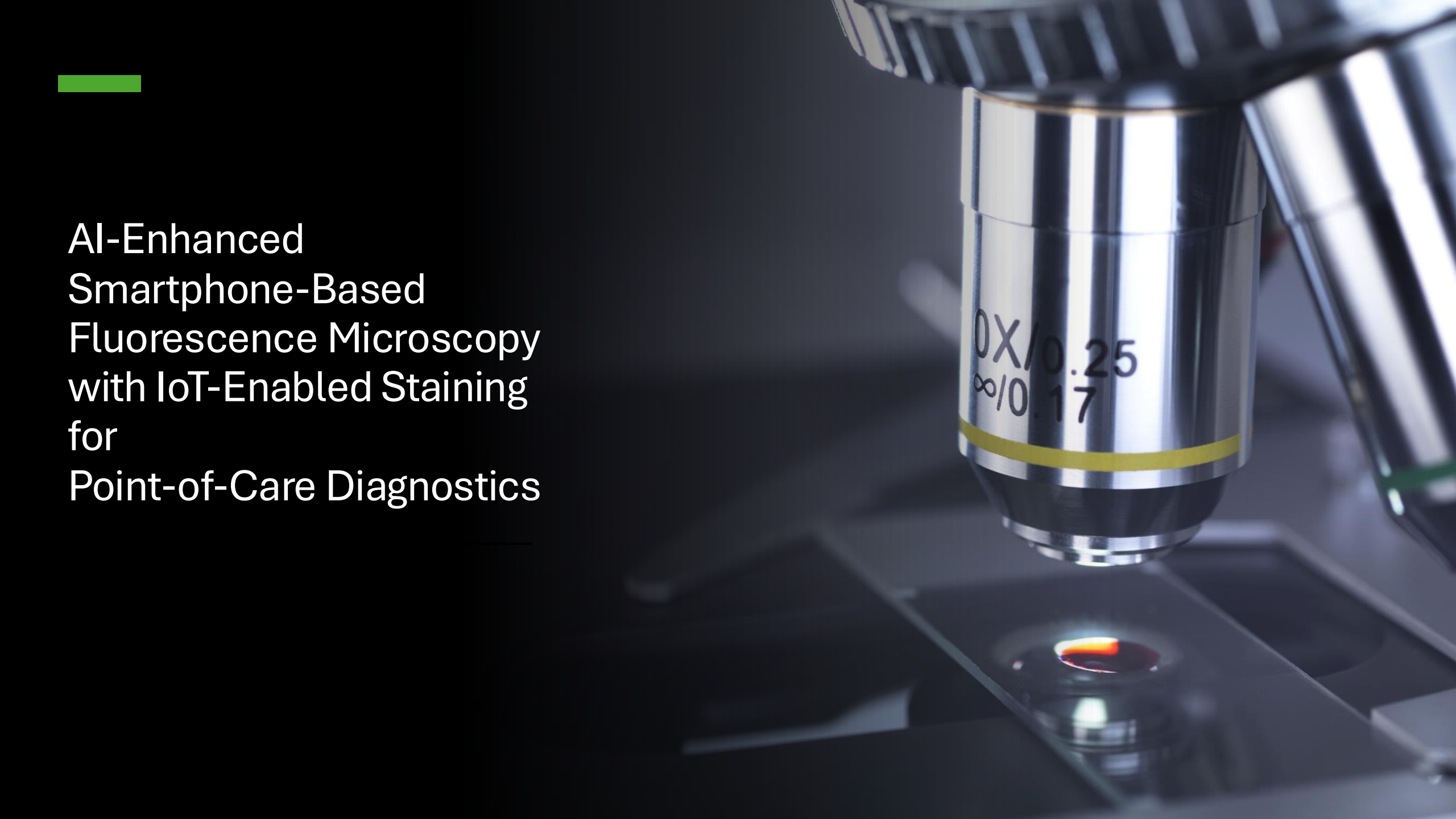
AI-Enhanced Smartphone-Based Fluorescence Microscopy with IoT-Enabled Staining for Point-of-Care Diagnostics



What we Know so far

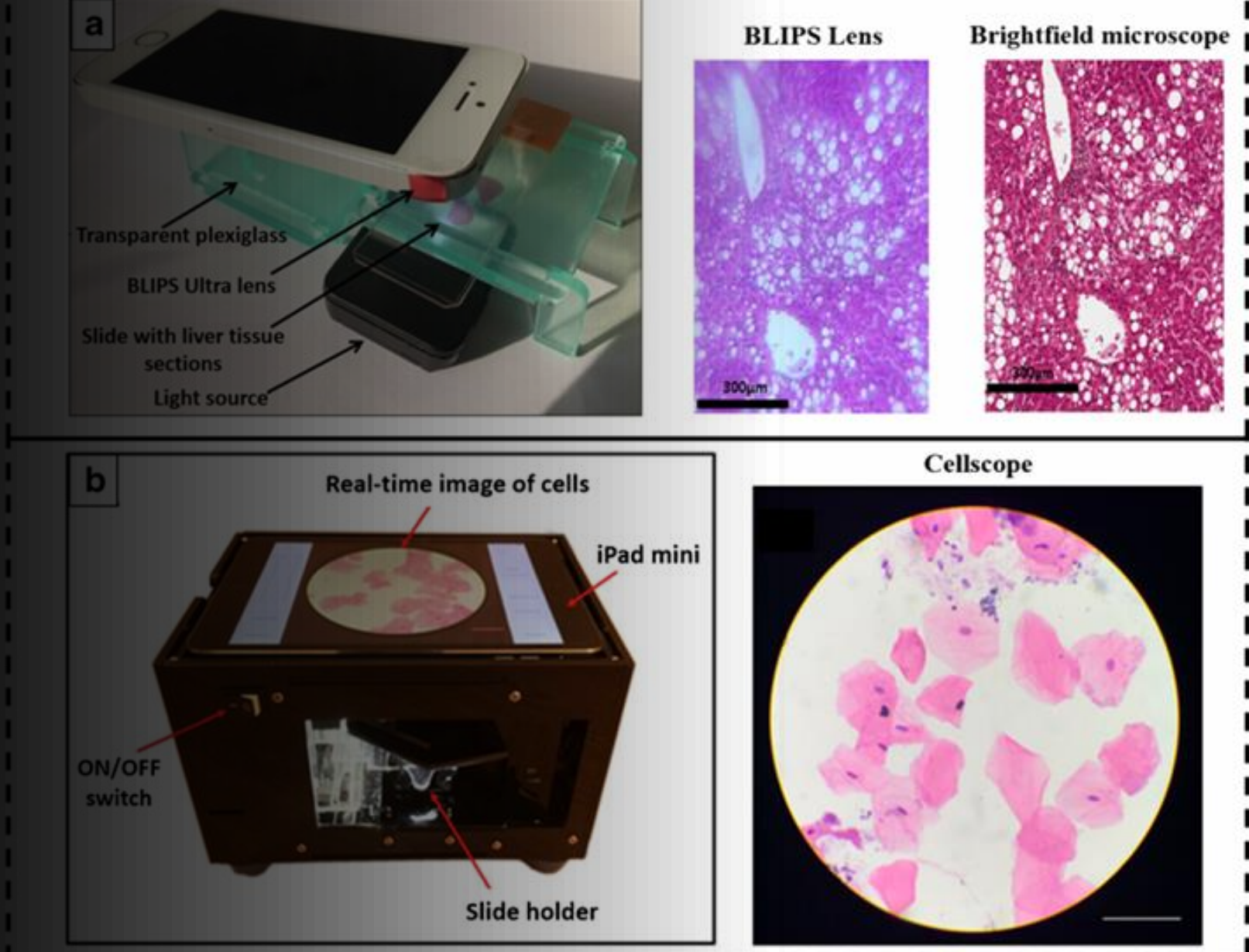
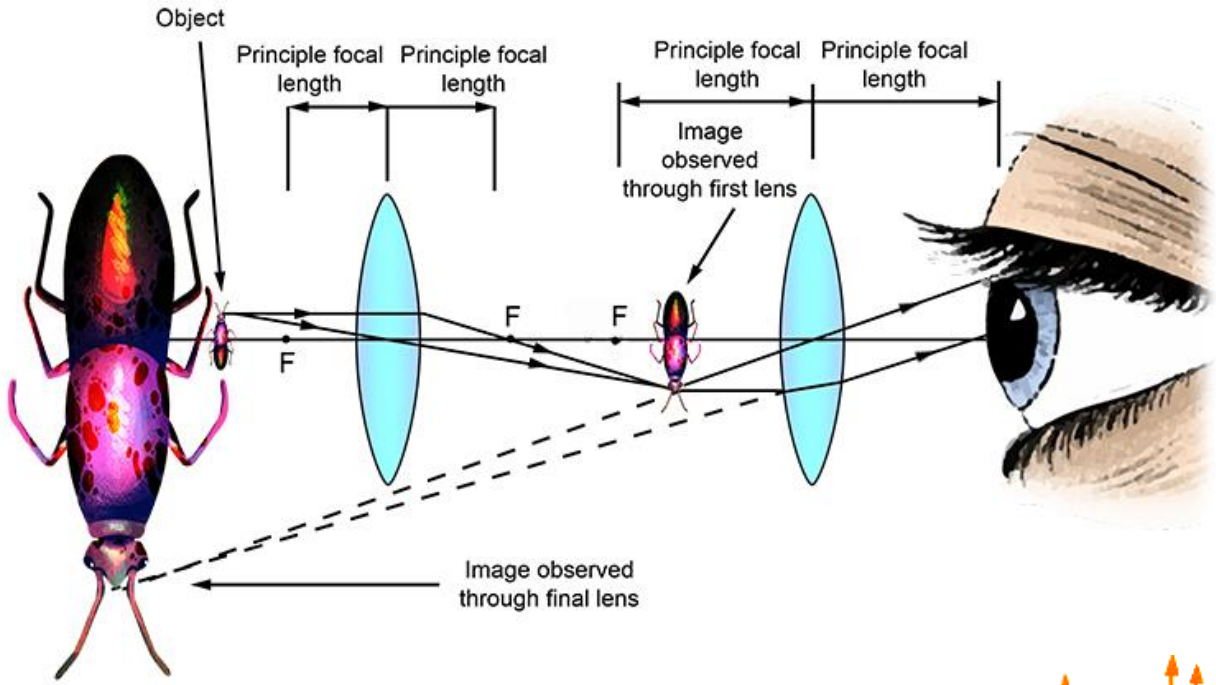


Fig. 1 Smartphone-based imaging system. **a** The BLIPS lens-based smartphone microscopic system along with the acquired images of human liver tissue section obtained and comparative image of the bright-field microscope. Reproduced from Cesaretti et al. [20], with permission from Jhon Wiley and Sons (copyright 2016). **b** The real-t acquisition of cancer cells. Reproduced from Skandarajah et al permission from PLOS (copyright 2017)

Working of compound microscope



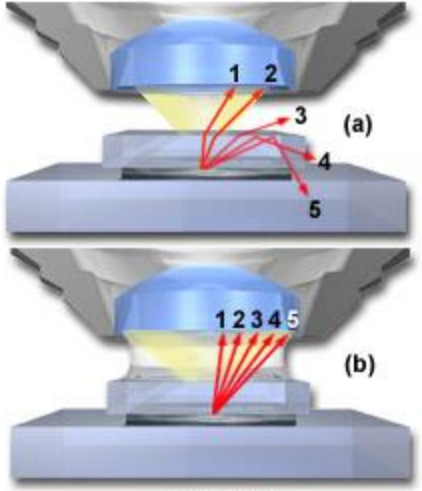
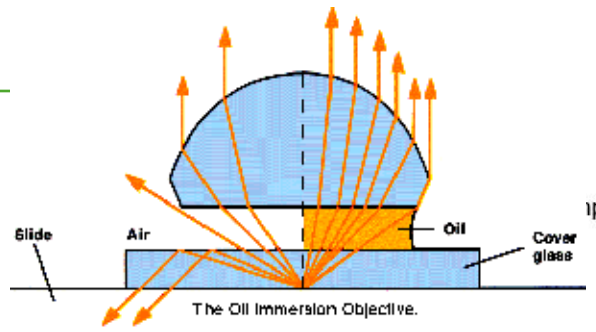
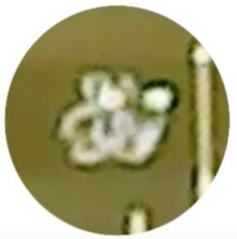
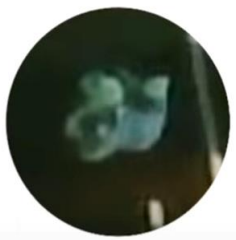


Figure 1



Types of Mobile microscopes

MICROSCOPE --->	AMSCOPE SM-4TZ-144A	AMSCOPE ME580TA-PZ-2L	SHIIRI	OXBIRD	ANNLOV	CAINDA	BYSAMEYEE 4KHD WIFI	TOMLOV DM201
ADVERTISED MAGNIFICATION	90-225X	500X	1000X	2000X	1000X	1000X	1000X	1200X
ACTUAL MAGNIFICATION	225X	500X	~100X	~100X	~100X	~100X	~50X	~50X
SENSOR	N/A	N/A	UNKNOWN	UNKNOWN	GC0308	GC0308	UNKNOWN	UNKNOWN
ADVERTISED RESOLUTION	N/A	N/A	NOT SPEC'D	NOT SPEC'D	8MP 1280X720	NOT SPEC'D	8MP 3840X2160	16MP
ACTUAL RESOLUTION	N/A	N/A	0.3MP 640X480	0.3MP 640X480	0.3MP 640X480	0.3MP 640X480	8MP 3840X2160	16MP 3840X2160
CONNECTIVITY	N/A	N/A	USB	USB	USB	USB	WIFI & USB	MICRO SD, HDMI
PRICE	$654.99	$992.99	$9.99	$12.99	$49.99	$22.99	$39.99	$169.99
SONIC DOODLE (NORMALIZED)								

Types of Digital microscopes

Types of Compound microscopes

Types of Microscope cameras

Limitations

- Lighting
- Design

Development of a low-cost smartphone fluorescence microscope.

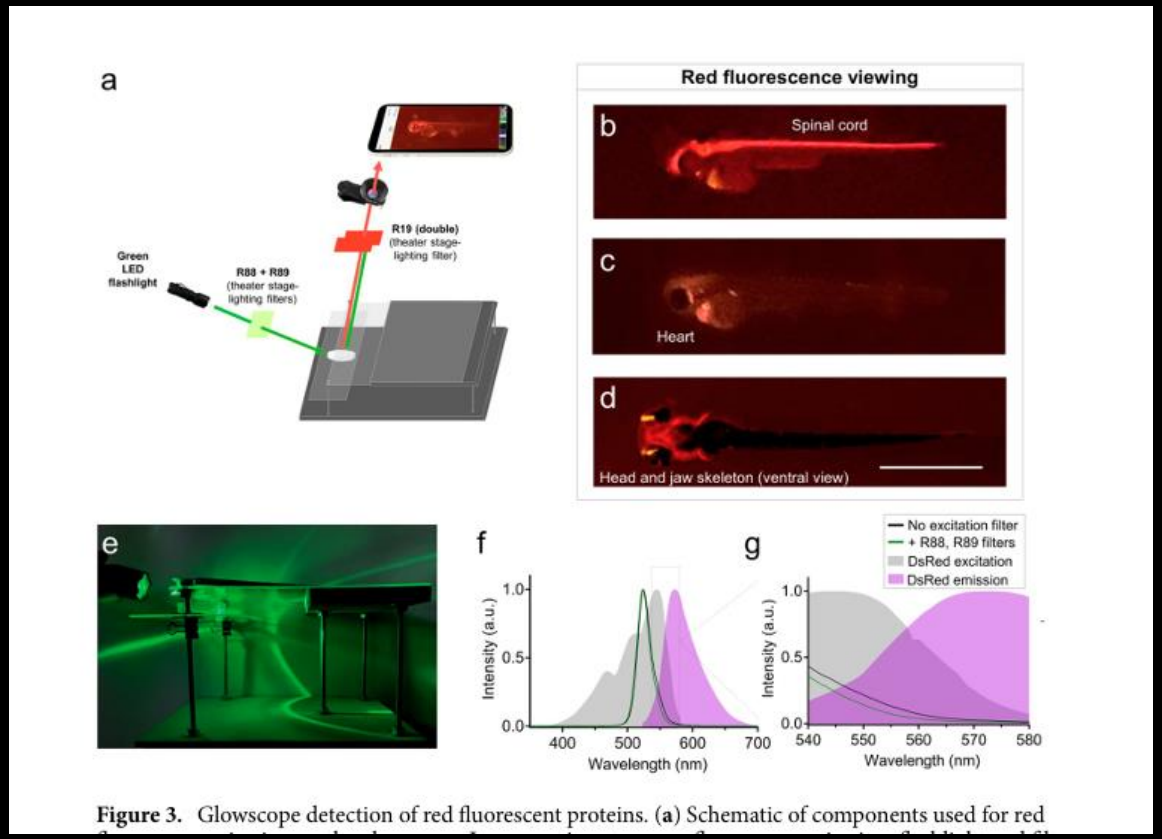


Figure 3. Glowscope detection of red fluorescent proteins. (**a**) Schematic of components used for red

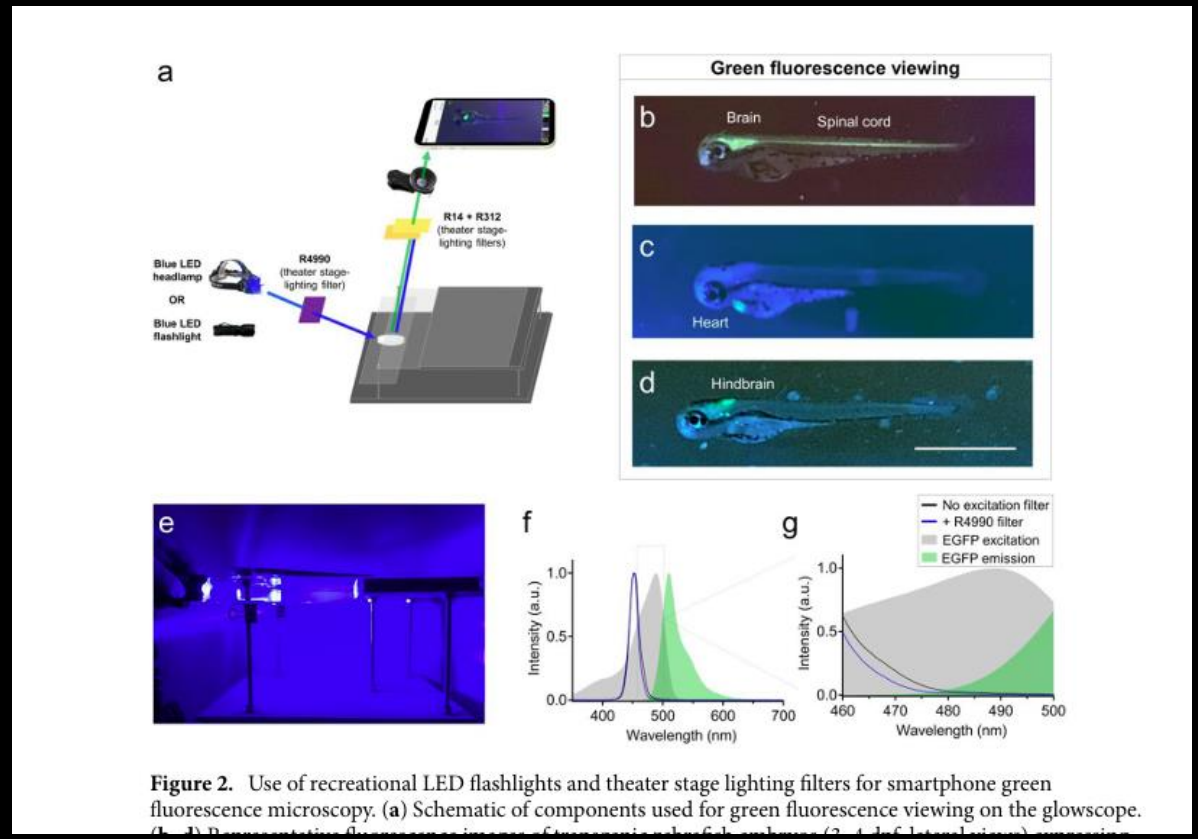


Figure 2. Use of recreational LED flashlights and theater stage lighting filters for smartphone green fluorescence microscopy. (**a**) Schematic of components used for green fluorescence viewing on the glowscope.

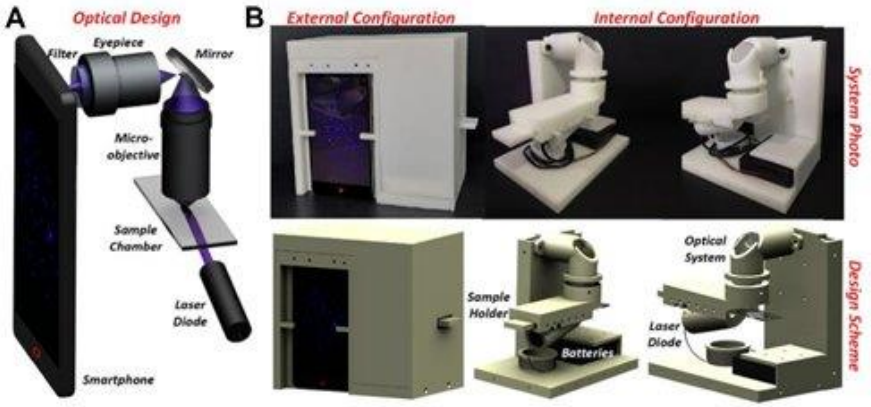


Fig. 4 Smartphone-based fluorescence microscope. **A** The optical design of the smartphone fluorescence microscope. **B** System photo and design sketch of the smartphone fluorescence microscope. (Figure reproduced from Shan et al., 2019 with permission from Elsevier).

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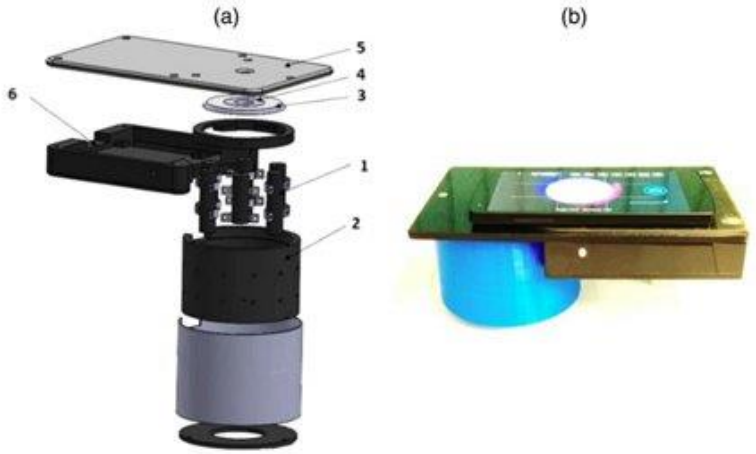


Fig. 5 **a** 3-D model of the three-wavelength illumination unit and **b** the mobile prototype with a smartphone on it. (1) Laser modules (three pairs, 448–532–659 nm), (2) shielding cylinder, (3) beams collector, (4) diffuser of LASER light, (5) sticky platform, and (6) electronics compartment. (Figure reproduced from Spigulis et al., 2017 with permission from SPIE).

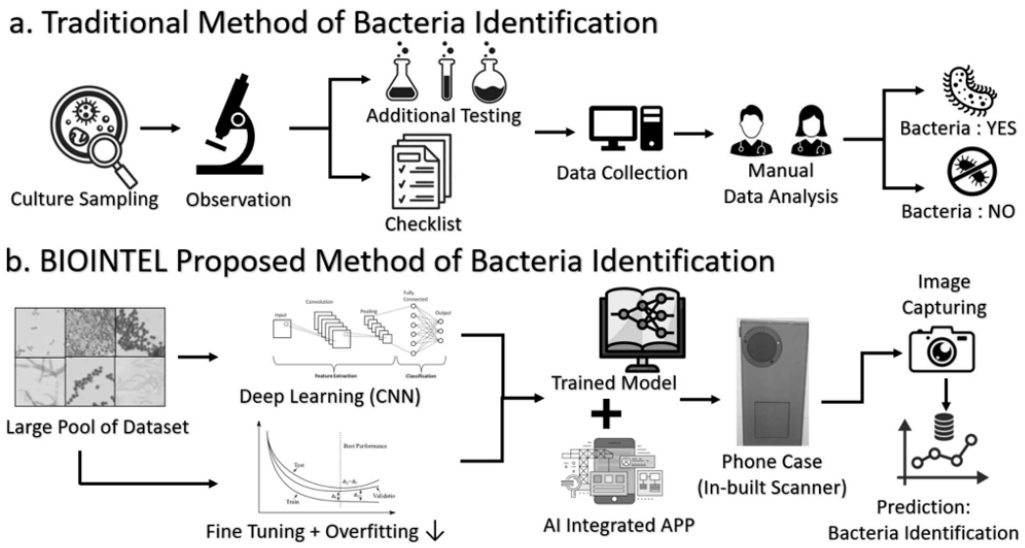


Fig. 1. Comprehensive pipeline of BioIntel system.

Cell/Tissue analysis

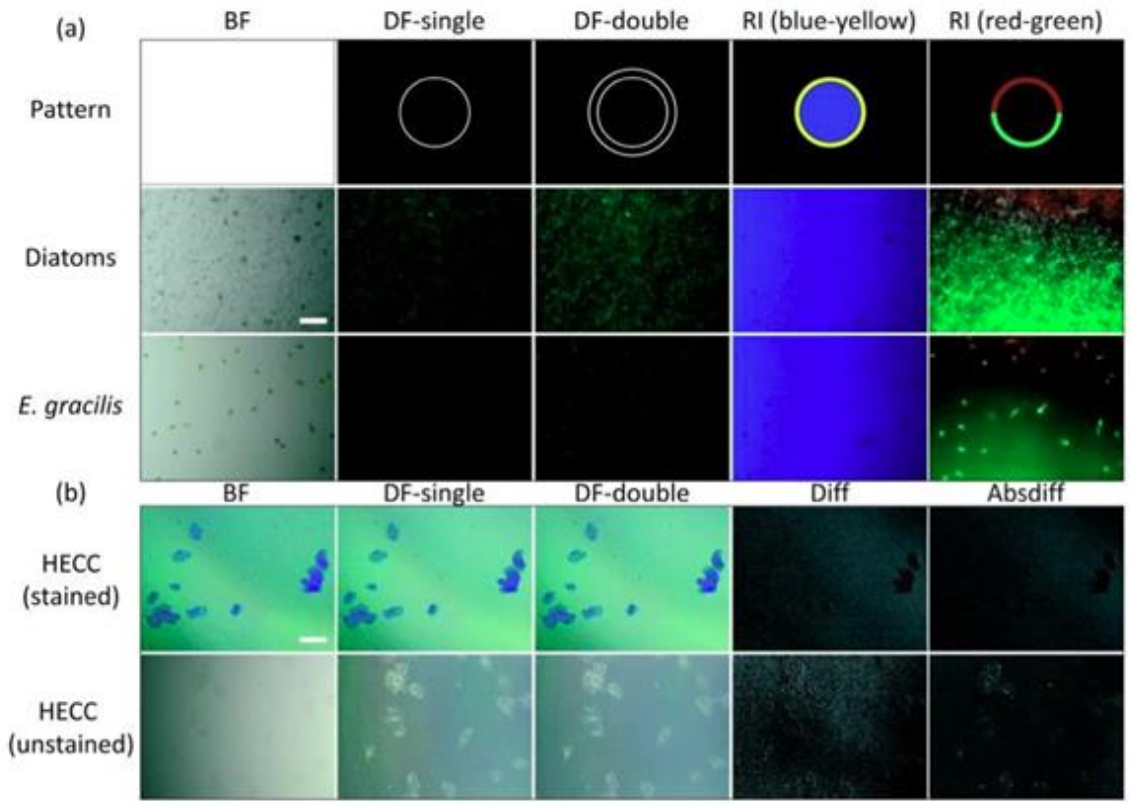
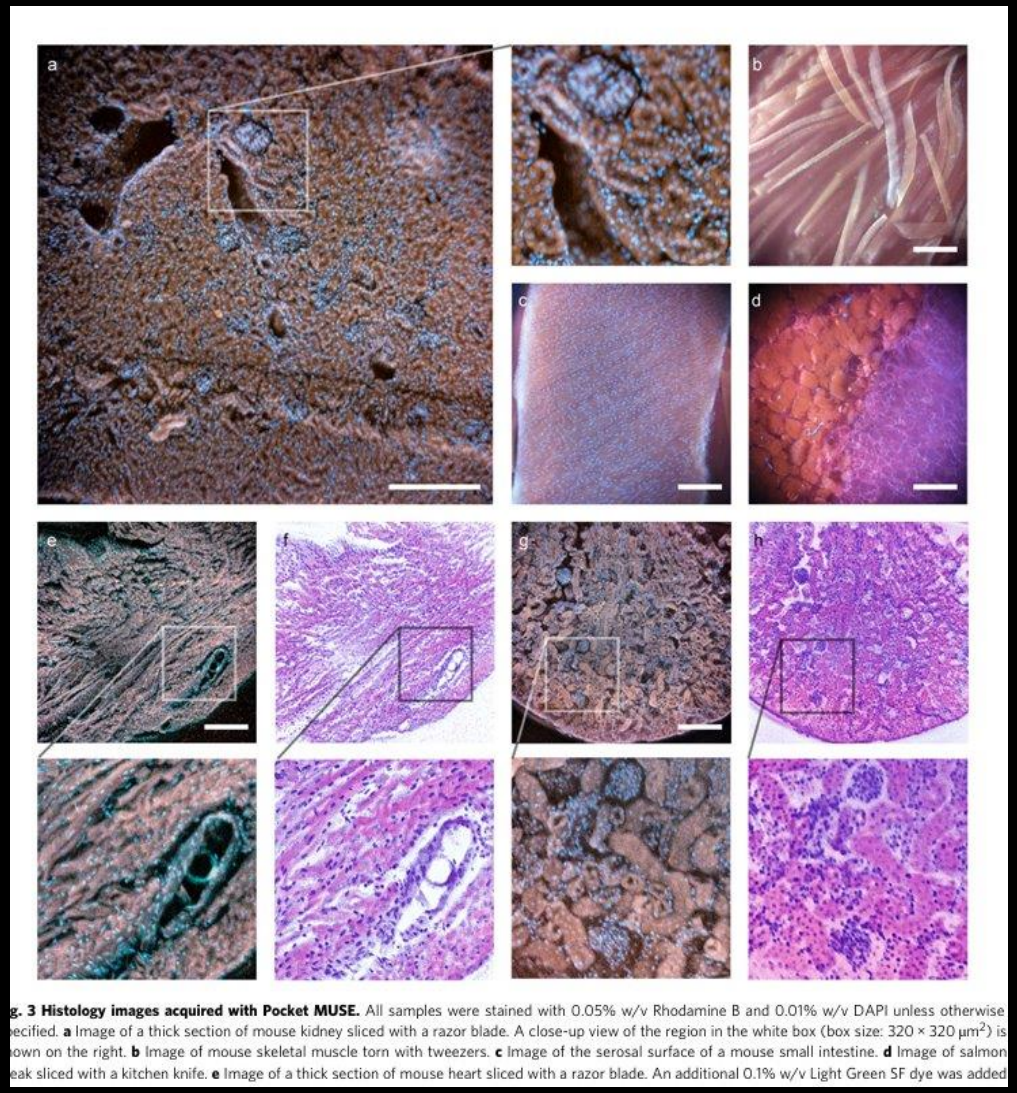


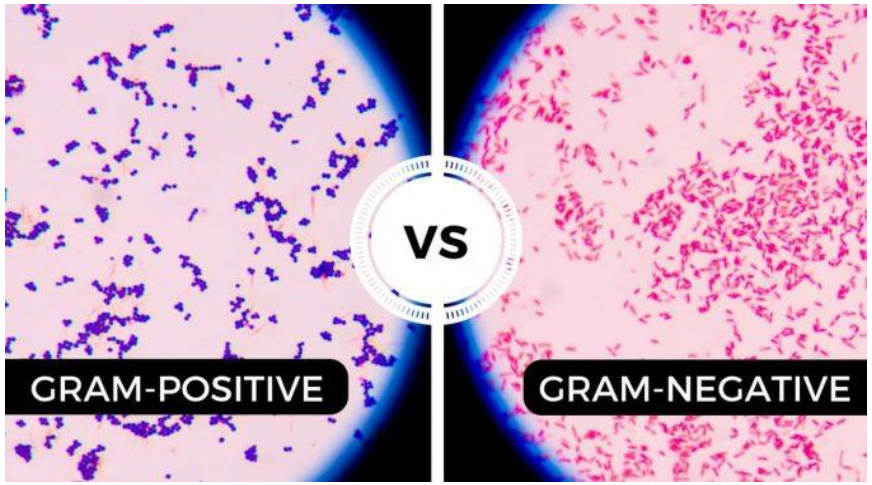
Fig. 6 Applications to imaging cells with various illumination patterns. **a** Diatoms and *E. gracilis* images zoomed in and cropped under bright-field (BF), dark-field (DF), and Rheinberg (RI) illumination patterns (second and third rows). In the top row, these illumination patterns were created using the Retina display. Used ring illumination patterns with single dark-field (DF-single) and double dark-field (DF-double) (second and third columns). On a dark specimen background, different types of RI were prepared: blue-yellow patterns (fourth column), and half-rings with multiple colors (red-green half-ring pattern) (fifth column). **b** Images of stained (methyl blue) and unstained human epithelial cheek cells (HECC) under BF and DF illumination patterns, zoomed in and cropped. Images from the second column were subtracted using a single dark-field (DF-single) illumination pattern. (Figure has been reproduced from Kheireddine S. et al., 2019 with permission from RSC publication).



g. 3 Histology images acquired with Pocket MUSE. All samples were stained with 0.05% w/v Rhodamine B and 0.01% w/v DAPI unless otherwise pecified. **a** Image of a thick section of mouse kidney sliced with a razor blade. A close-up view of the region in the white box (box size: 320 × 320 μm^2) is own on the right. **b** Image of mouse skeletal muscle torn with tweezers. **c** Image of the serosal surface of a mouse small intestine. **d** Image of salmon eak sliced with a kitchen knife. **e** Image of a thick section of mouse heart sliced with a razor blade. An additional 0.1% w/v Light Green SF dye was added

Bacterial Sample Identification

- Limitation of resolution



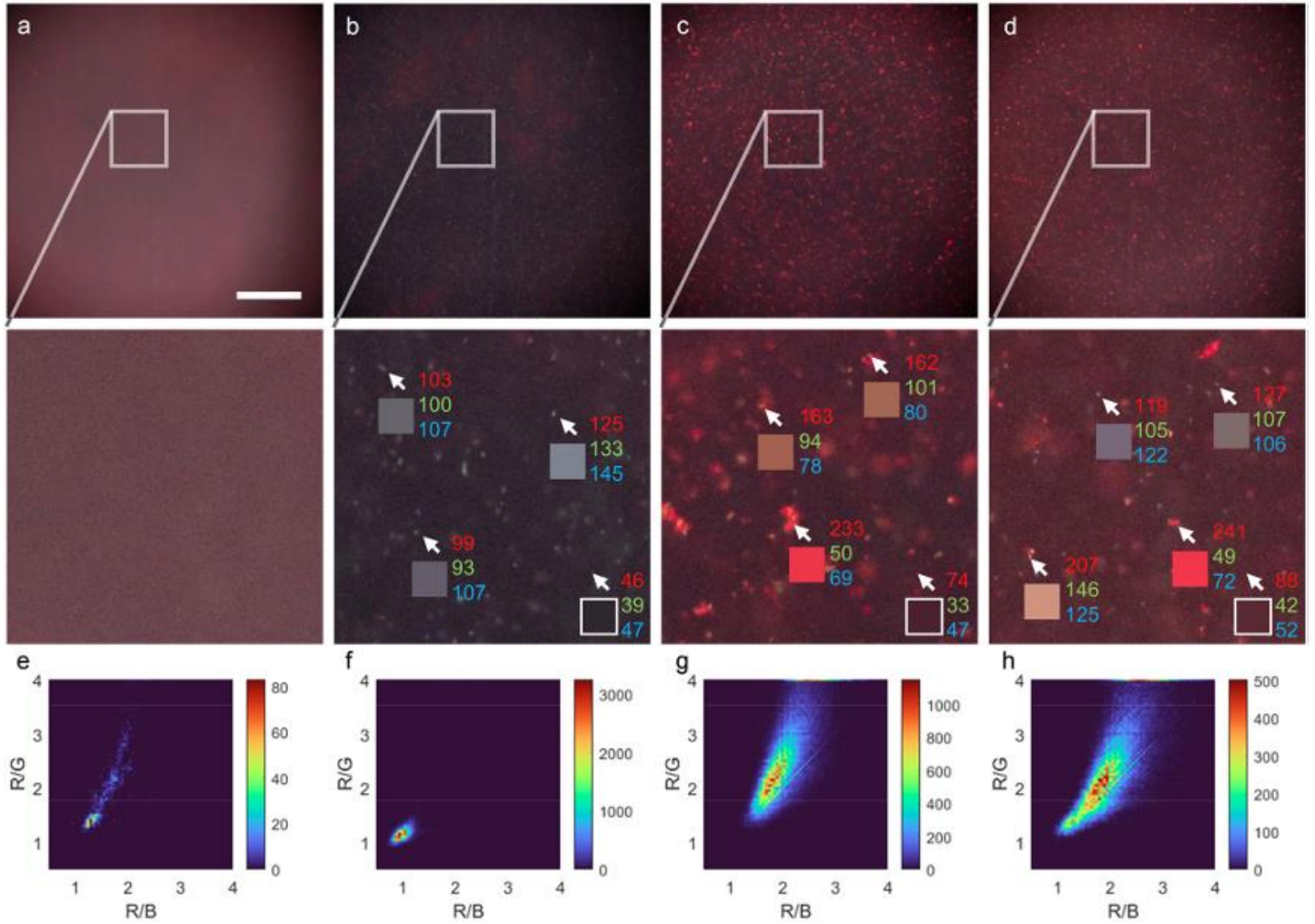


Fig. 9 Images of bacterial samples acquired with Pocket MUSE. Two different populations (Gram + and Gram-) of bacteria can be separated with Pocket MUSE. Aliquots of (**a**) deionized water, (**b**) an *E. coli* (Gram-) culture, (**c**) a *B. subtilis* (Gram +) culture, and (**d**) a mixture of E. coli culture and *B. subtilis* culture imaged with Pocket MUSE. All samples were stained with 0.01% w/v DAPI and 0.02 % w/v WGA-AF594, and imaged under the same conditions. Images show (**a**) no bright spots, (**b**) blue-grayish spots, (**c**) a mixture of reddish and orangish spots, and (**d**) a mixture of blue-grayish, reddish and orangish spots dispersed across the FOV. For each image, a close-up view of the region labeled with the box (box size: 250 × 250 μm^2) is shown below. For (**b**)-(**d**), the center pixels of three bright spots in each image, pointed to by the arrows, are shown in the boxes below. The RGB values (top to bottom) of the pixels are labeled on the side. The nucleic acid in *E. coli* (DAPI stain) contributes to the blue-grayish speckles ($R \approx G \approx B$). Peptidoglycan on the *B. subtilis* surface (WGA-AF594 stain) contributes to the reddish speckles ($R > G + B$). Nucleic-acid-rich endospores in *B. subtilis* contribute to the orangish

Proposal

Smartphone + AI + IoT = Point-of-Care Diagnosis

Smartphone fluorescence microscope

QR-coded slides → automatic model + staining selection

IoT-enabled staining system (CISS + Raspberry Pi)

AI-powered detection and diagnosis

Key Modules

- Smartphone Microscope with fluorescence
- AI for:
- Image preprocessing
- Pathogen classification
- Quality check
- IoT-Controlled Staining Unit:
- Raspberry Pi/Arduino + CISS
- QR-code-triggered stain protocol

Applications

- Infectious disease detection: malaria, TB, typhoid in rural area
- Water quality testing (pathogen load)
- Blood/sputum diagnostics in remote clinics
- Telemedicine integration
- Food Quality

- School/university science labs

Innovative Approach to Diagnosis

- **Smartphone + AI + IoT = Point-of-Care Diagnosis**
- Smartphone fluorescence microscope for rapid analysis
- QR-coded slides enable automatic model and stain selection
- IoT-enabled staining system using CISS and Raspberry Pi
- AI-powered detection ensures accurate diagnosis