



Digital Microscopy and Diagnosis on Cellphones

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Digital Diagnosis

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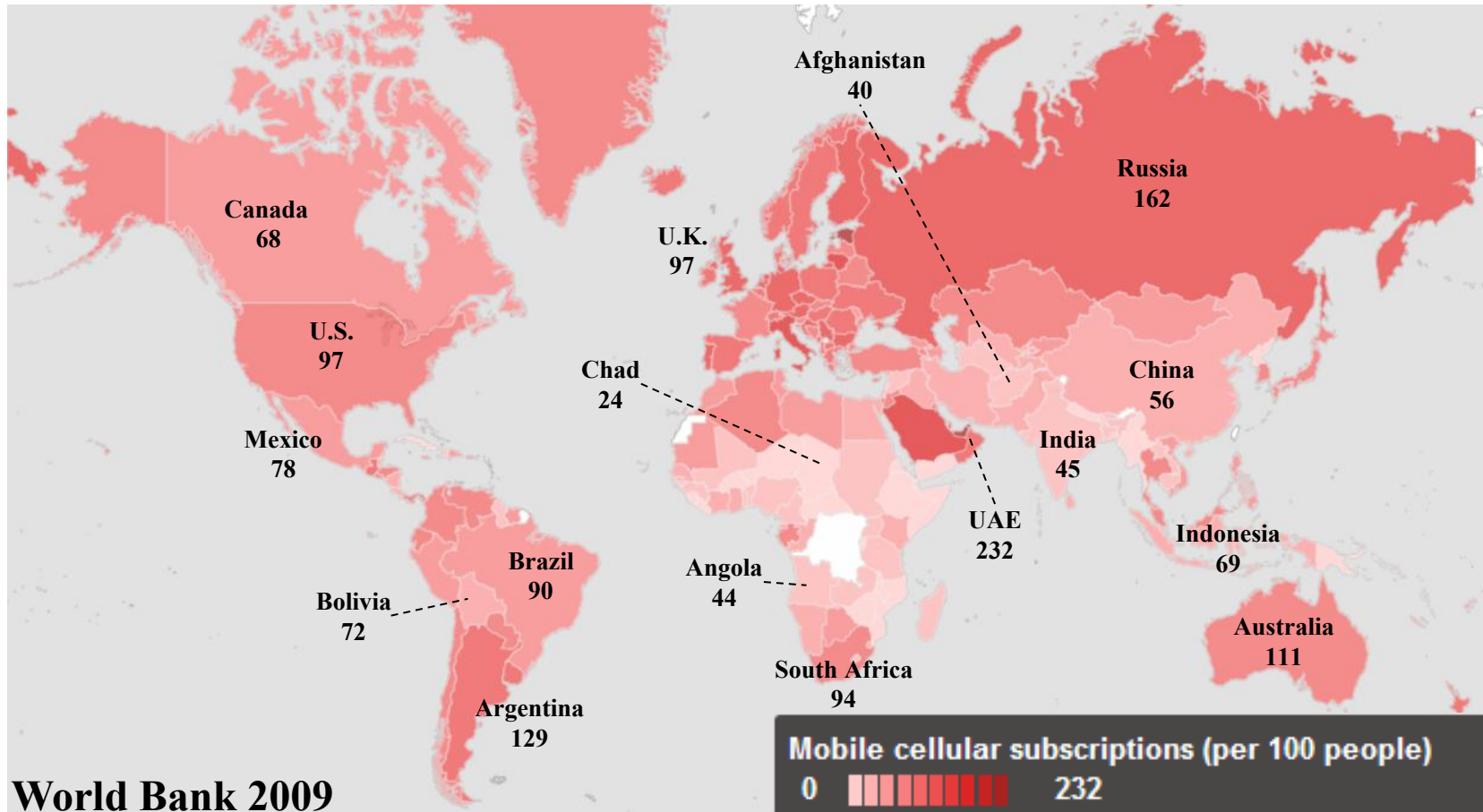
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June, 2012



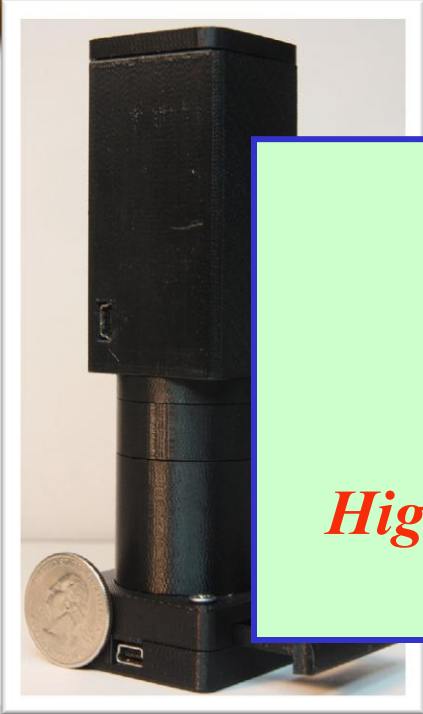
Cell phones are now everywhere: A great potential for Telemedicine needs



- > 5 billion cell phones are being used worldwide.
- > 70% are in developing countries. (ITU, 2010).



Providing a new platform for telemedicine



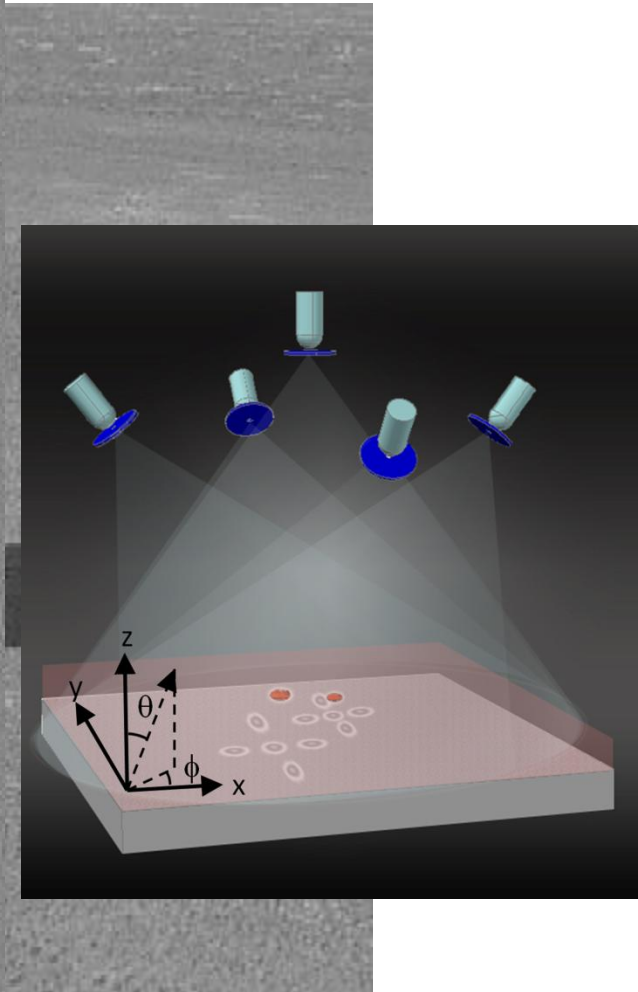
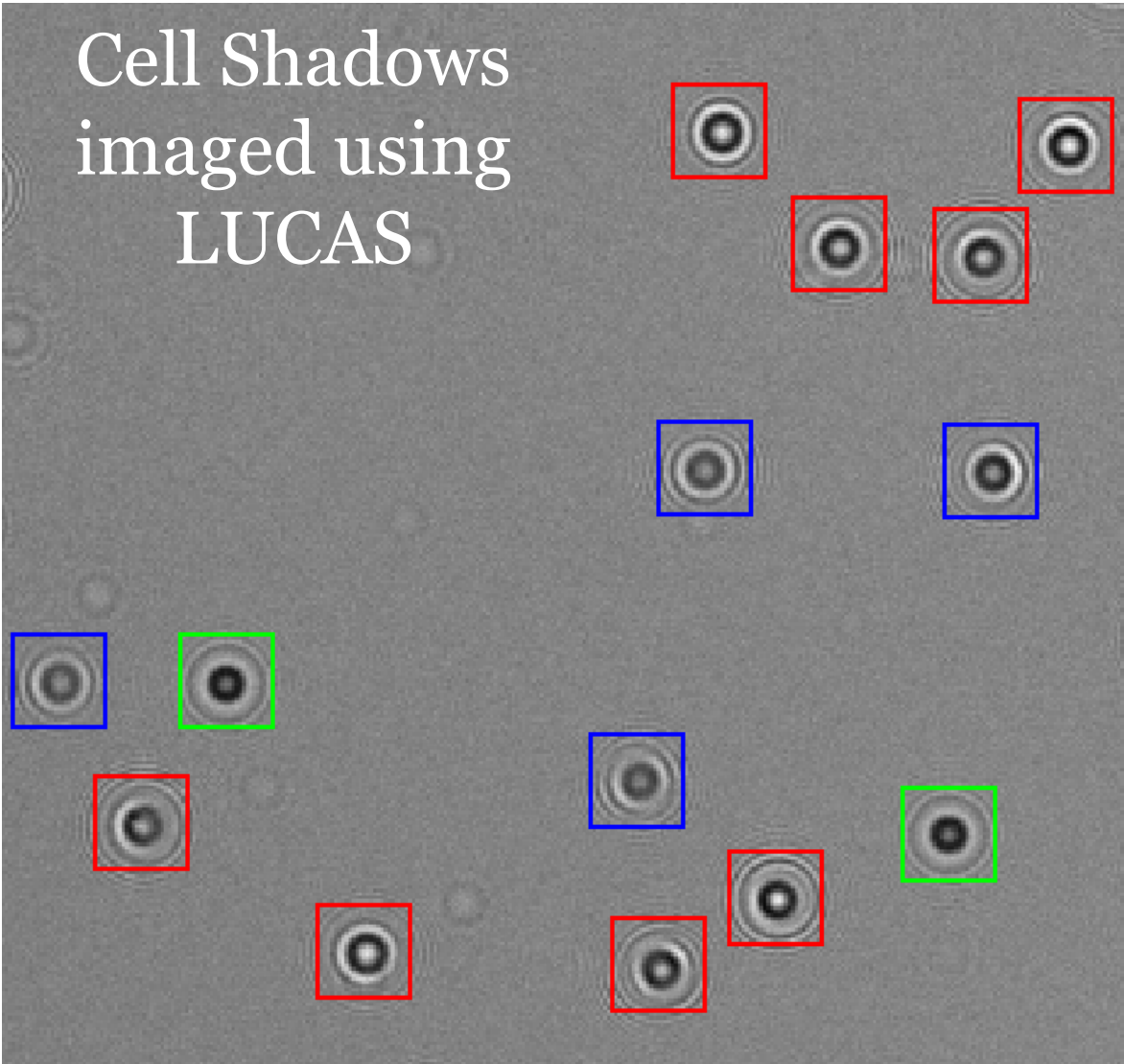
LUCAS:
Lensfree (On-Chip Imaging)
Compact, Cost-effective
High-throughput
Highly sensitive (Incoherent Holography)
Tolerant to Misalignments

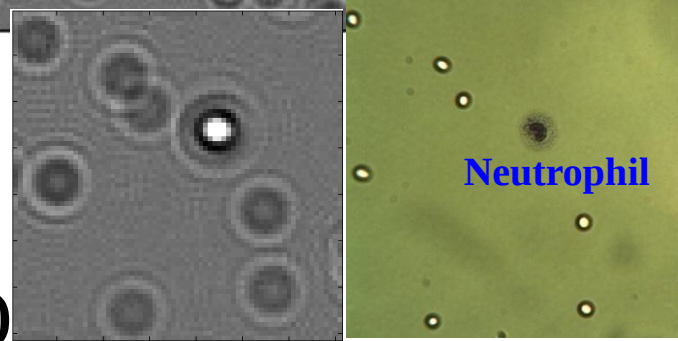
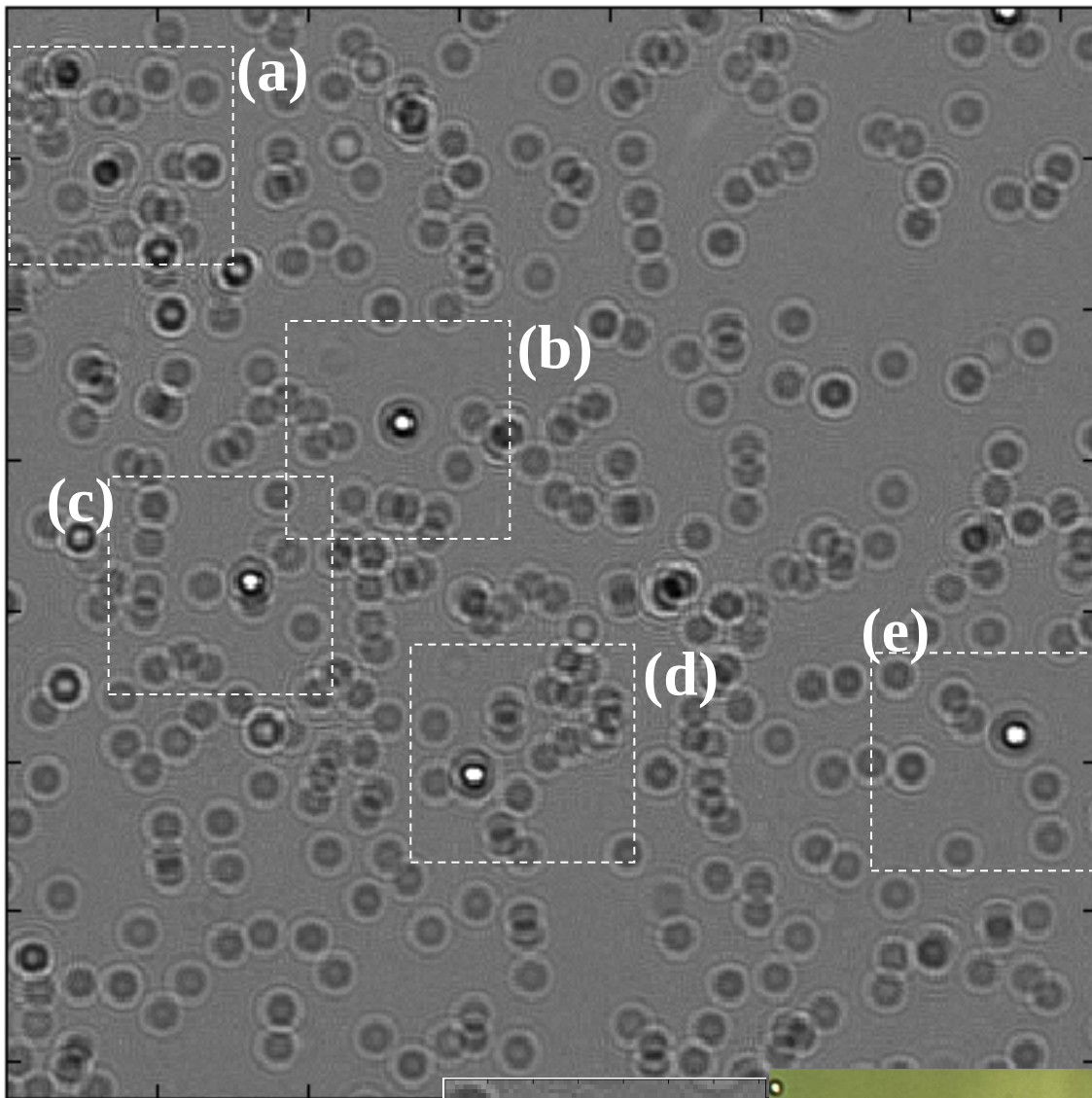
LUCAS: *L*ensless, *U*ltra wide-field *C*ell monitoring *A*rray platform
based on *S*hadow imaging



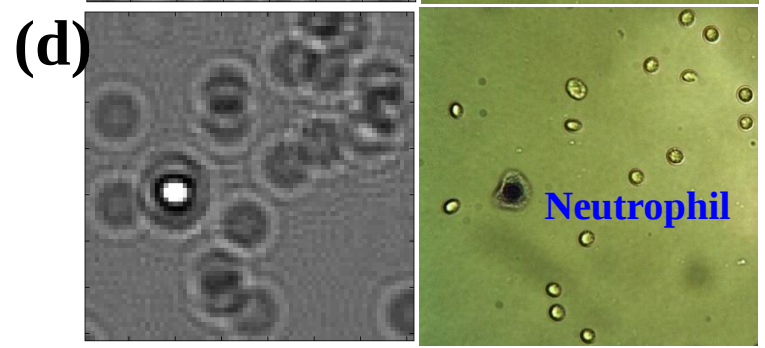
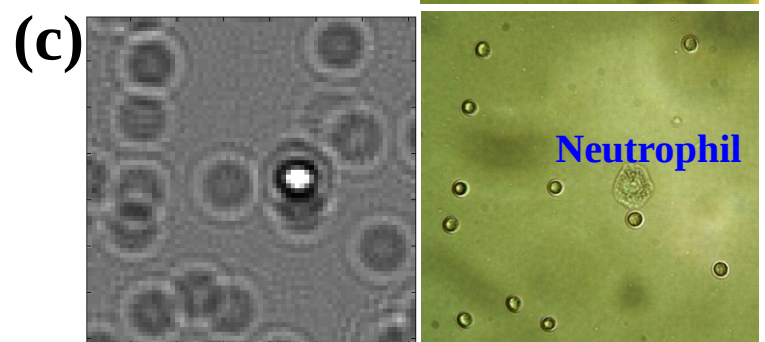
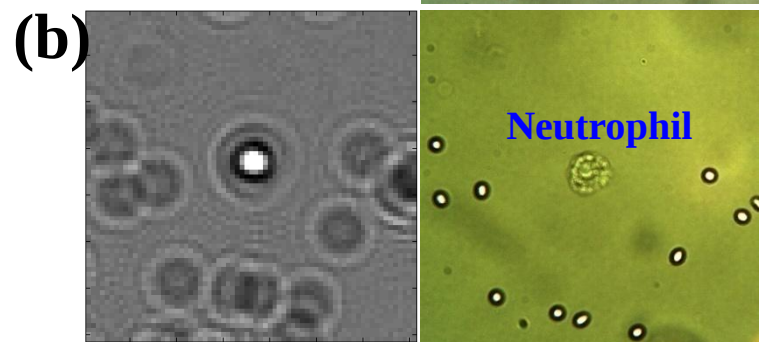
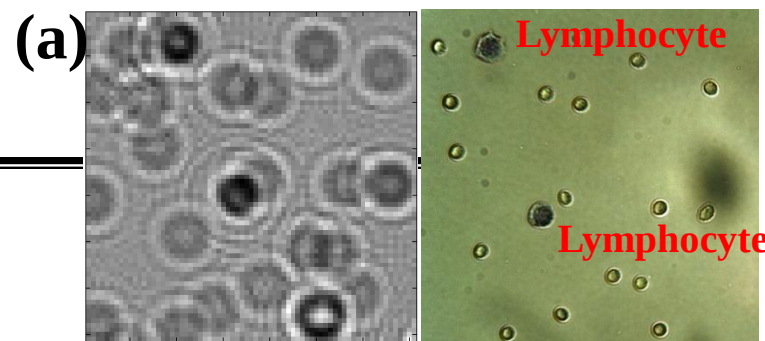
Imaging of shadows

Cell Shadows
imaged using
LUCAS

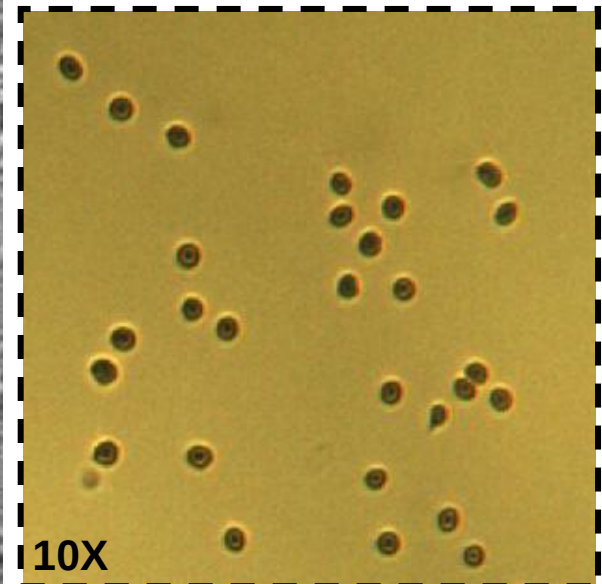
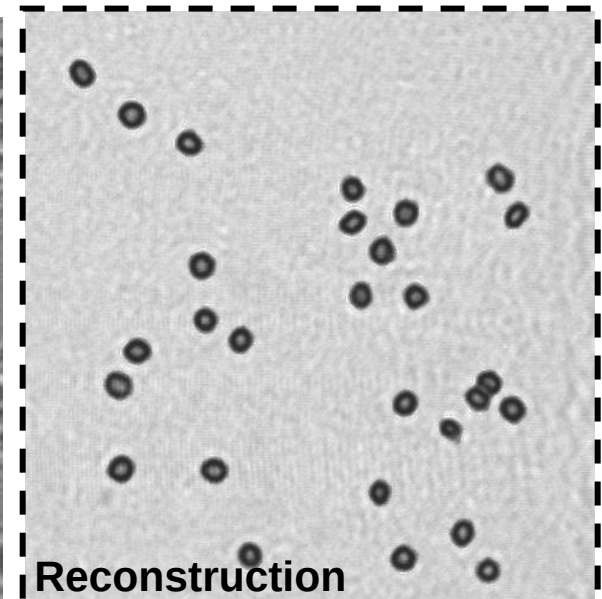
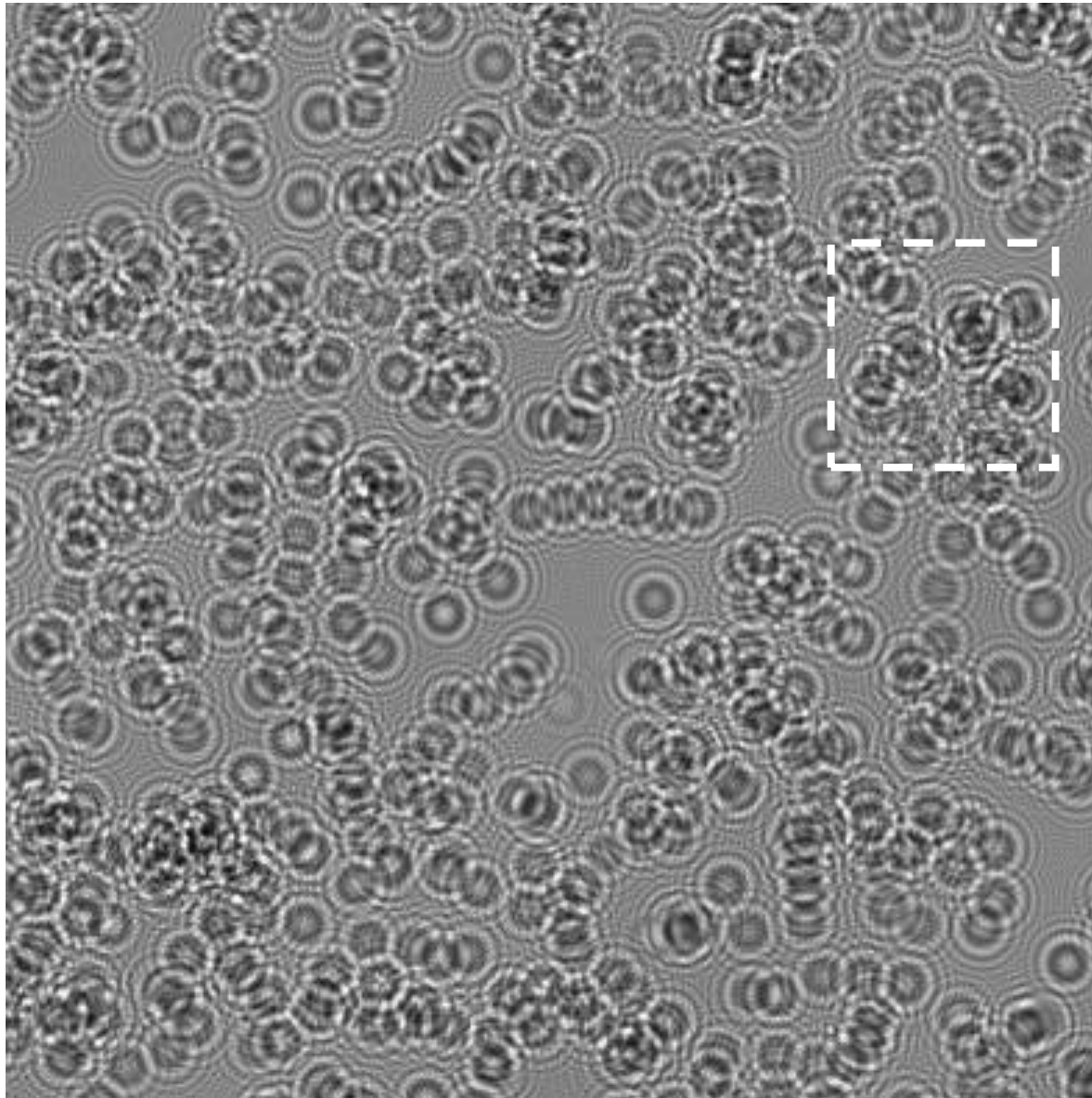


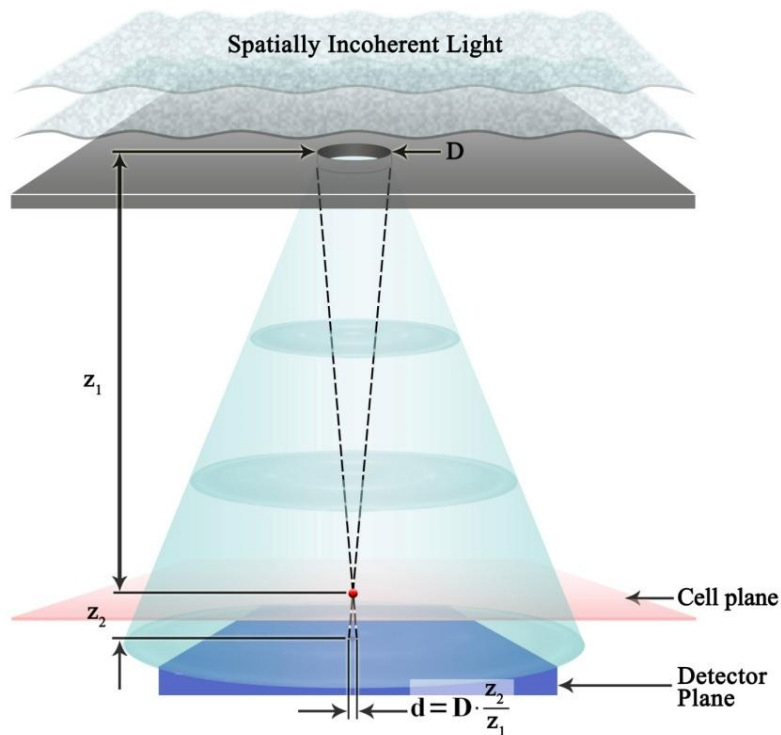


(e)



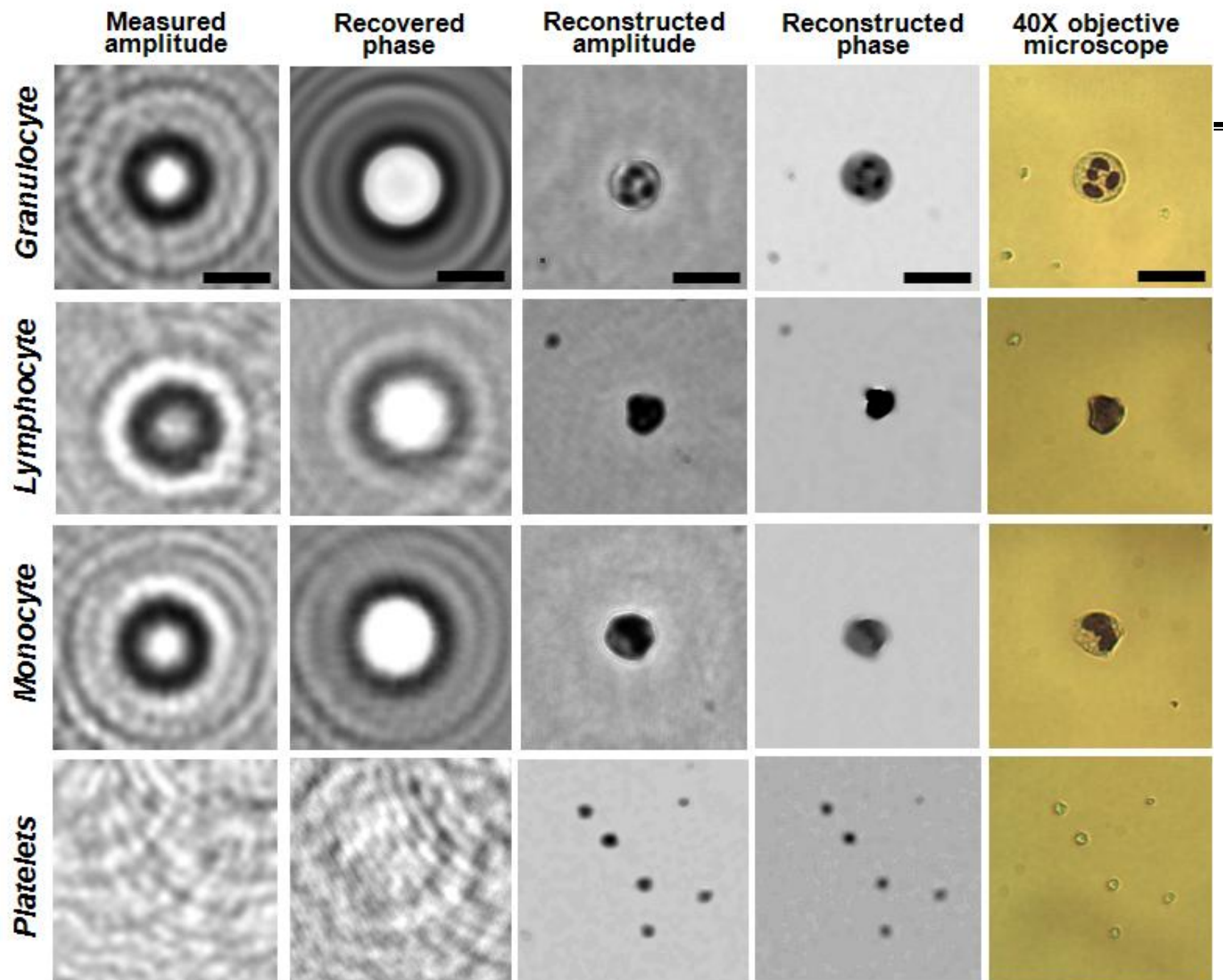
Cell Density: 102K [Cells/uL]





Incoherent Lensfree Holography Using Large Apertures:

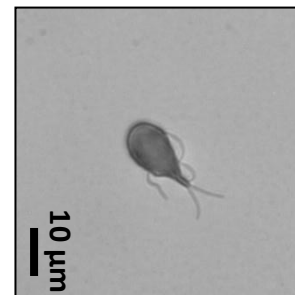
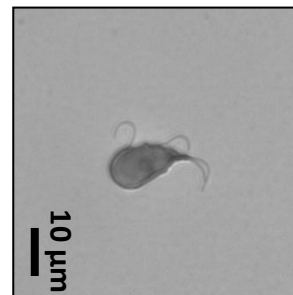
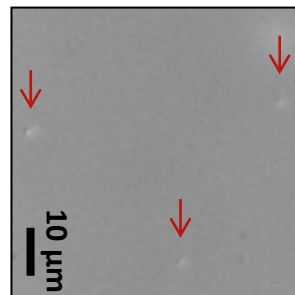
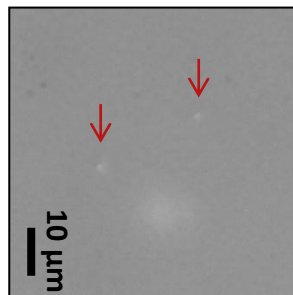
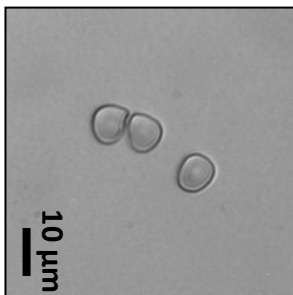
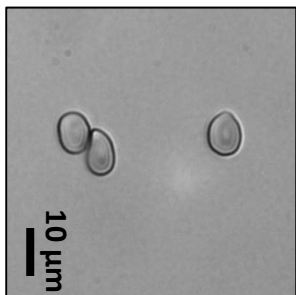
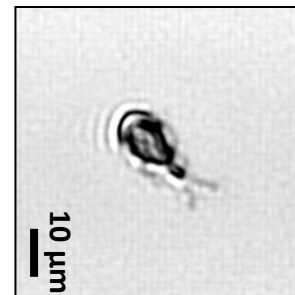
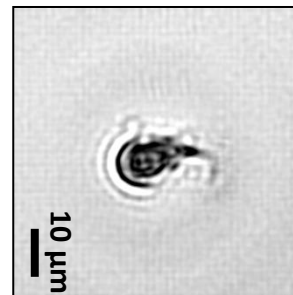
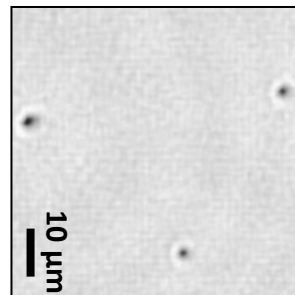
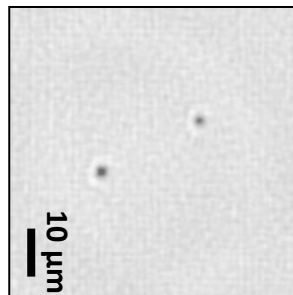
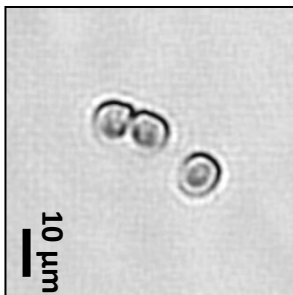
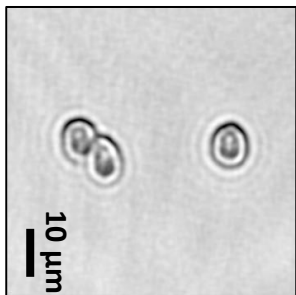
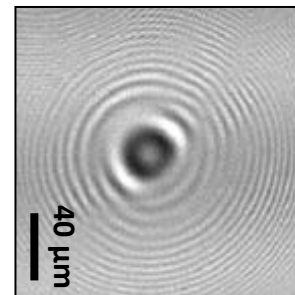
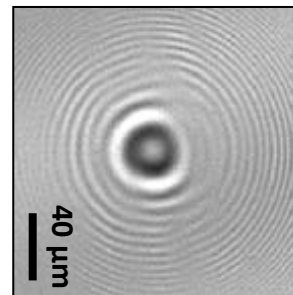
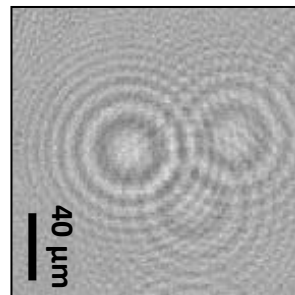
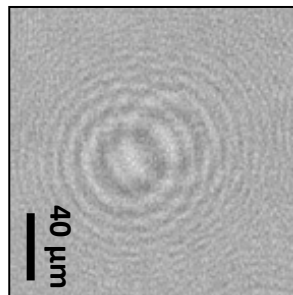
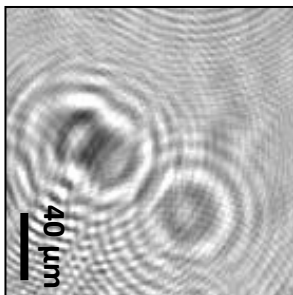
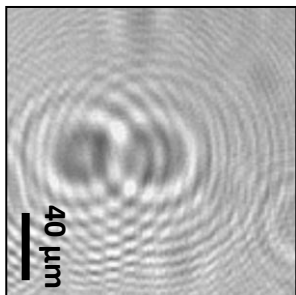
- Reduced speckle noise and multiple interference noise*
- Reduced cross-talk among cells*
- Tolerant to misalignments; No need for coupling optics*
- No need for lasers; LEDs would be sufficient*
- Significantly larger field of view*



Red Blood Cells

Escherichia Coli (E. Coli)

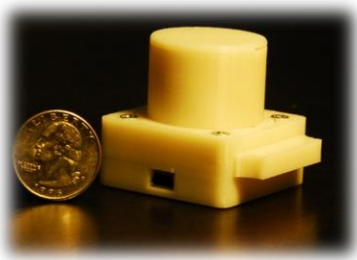
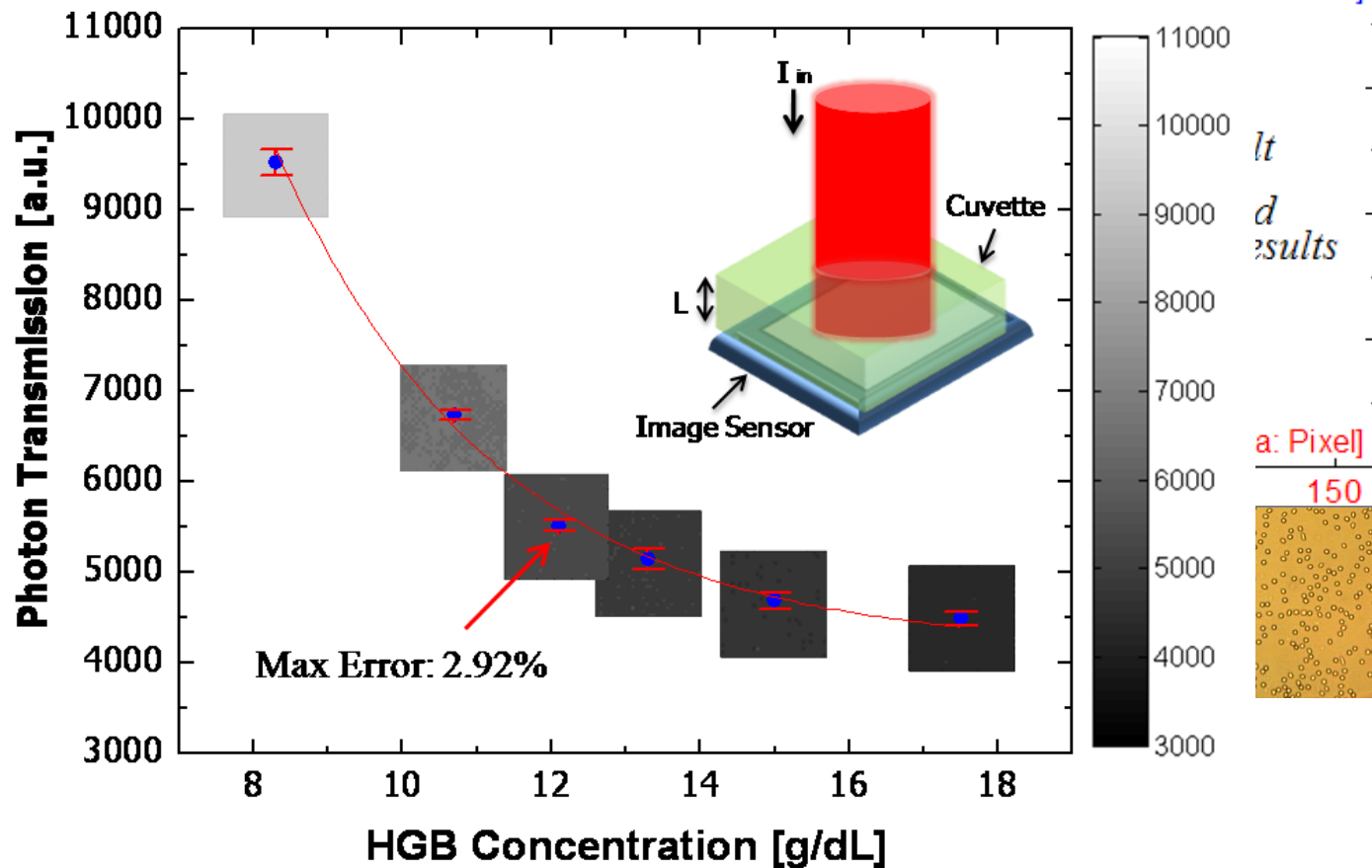
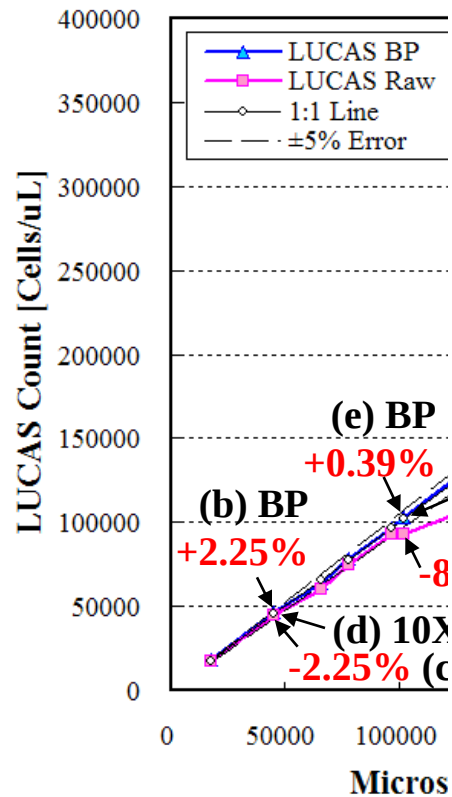
Giardia L. Trophozoites





Blood Analysis using LUCAS

LUCAS Counting Accuracy for RBC





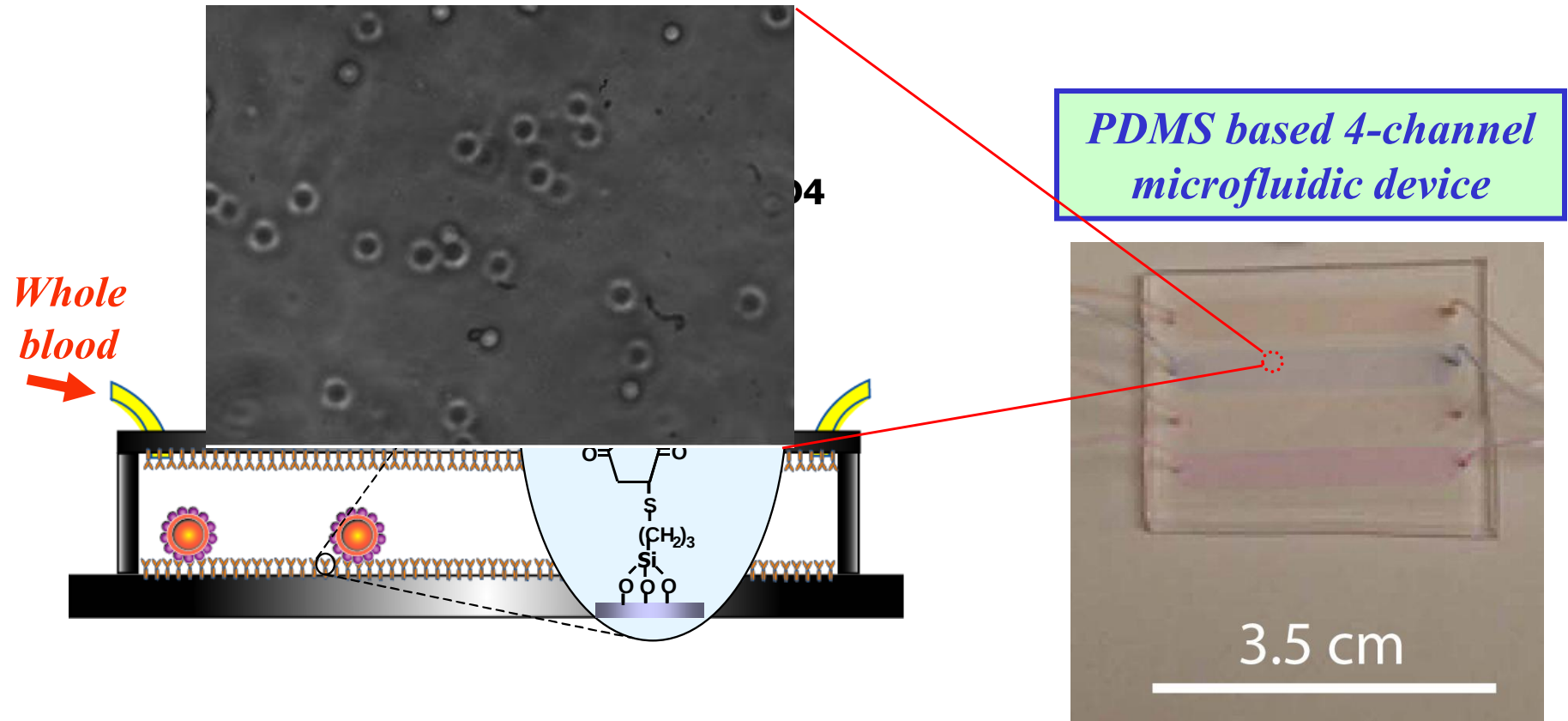
Monitoring HIV patients in resource limited settings is an important challenge



A girl living with HIV in Malawi



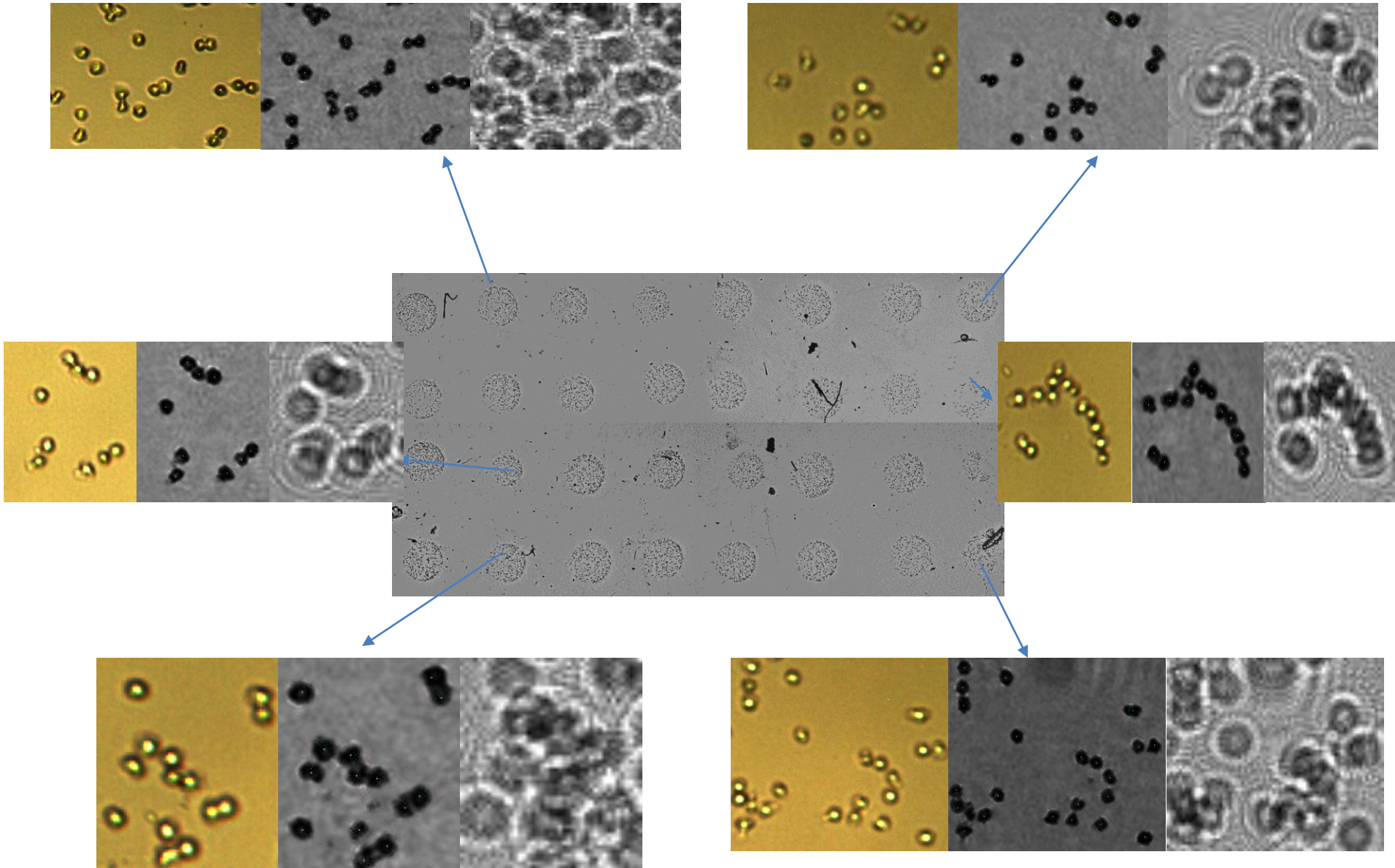
Cell counting in microfluidic channels based on LUCAS



We can achieve a specificity of >90% and an efficiency of 90% for capturing CD4 cells from whole blood.

Collaborator: Revzin Group UC Davis

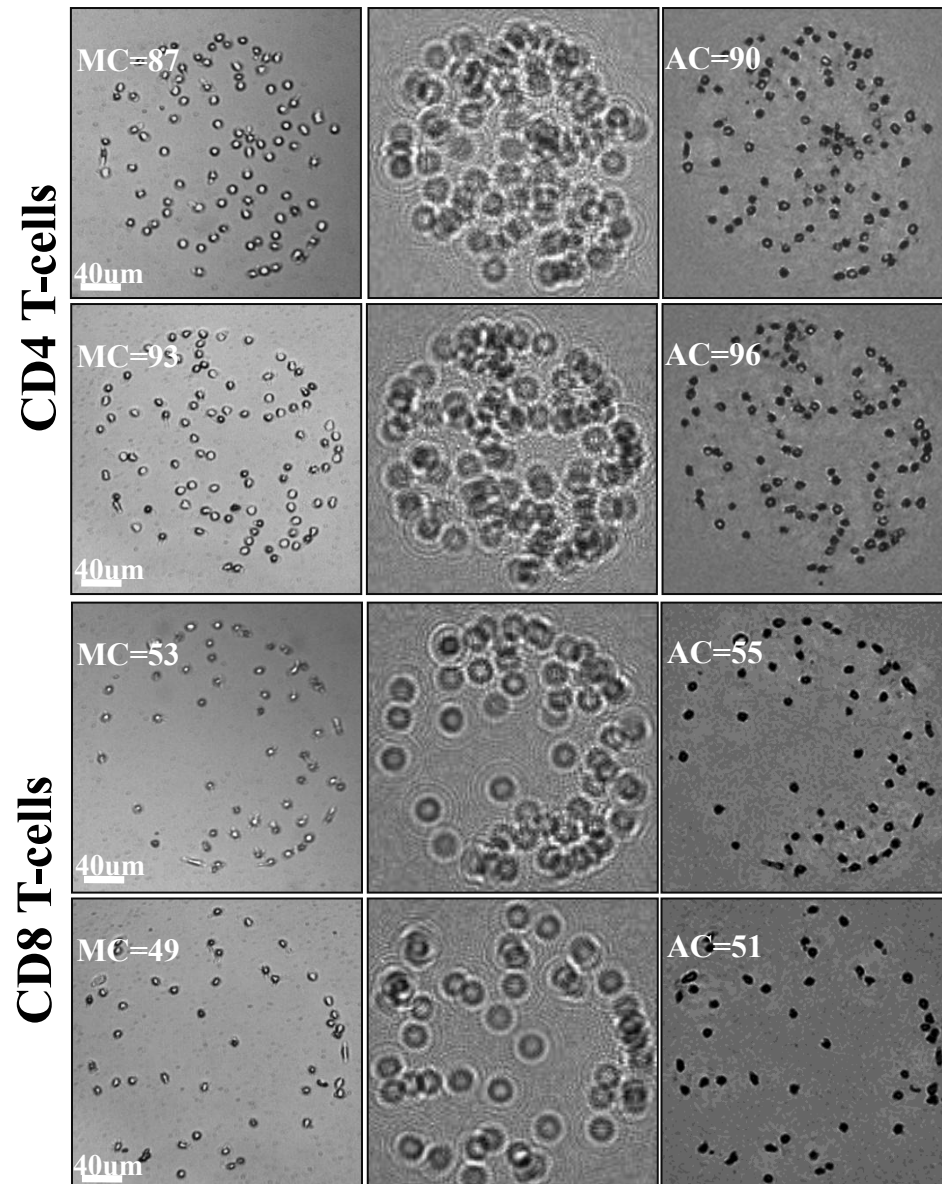
CD4 CD8 counts using LUCAS

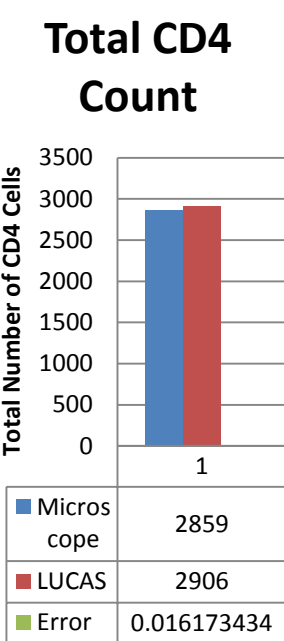
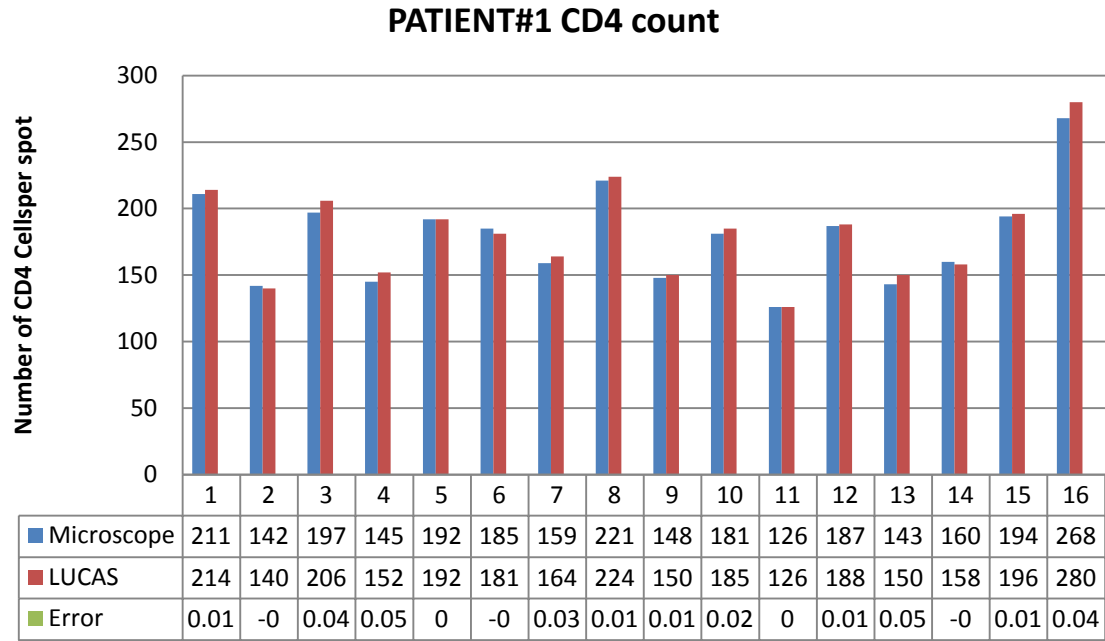
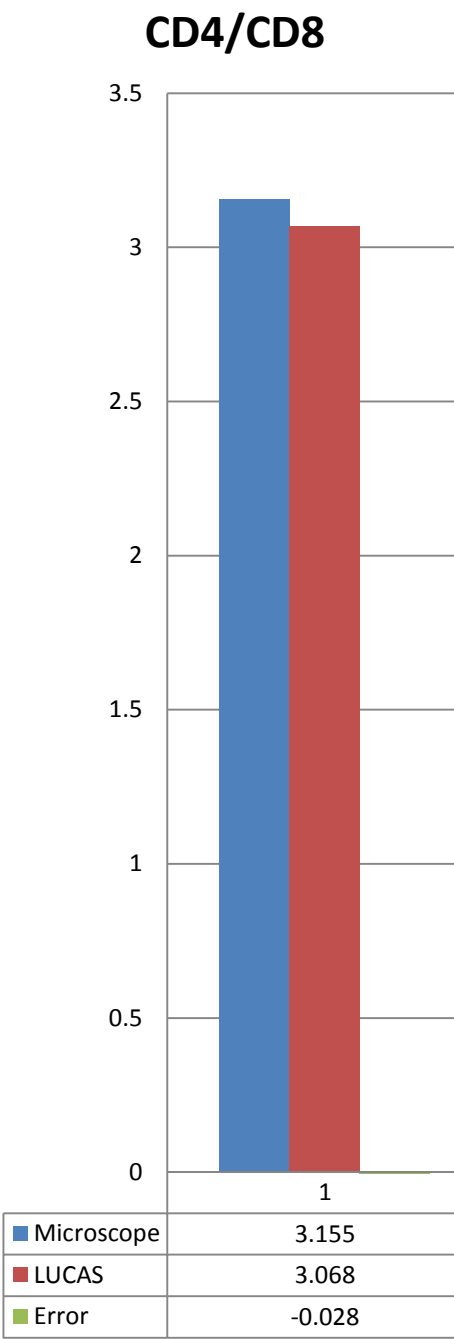
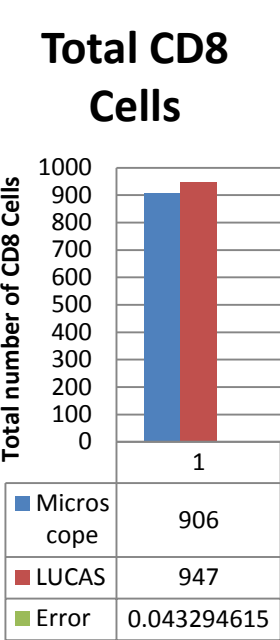
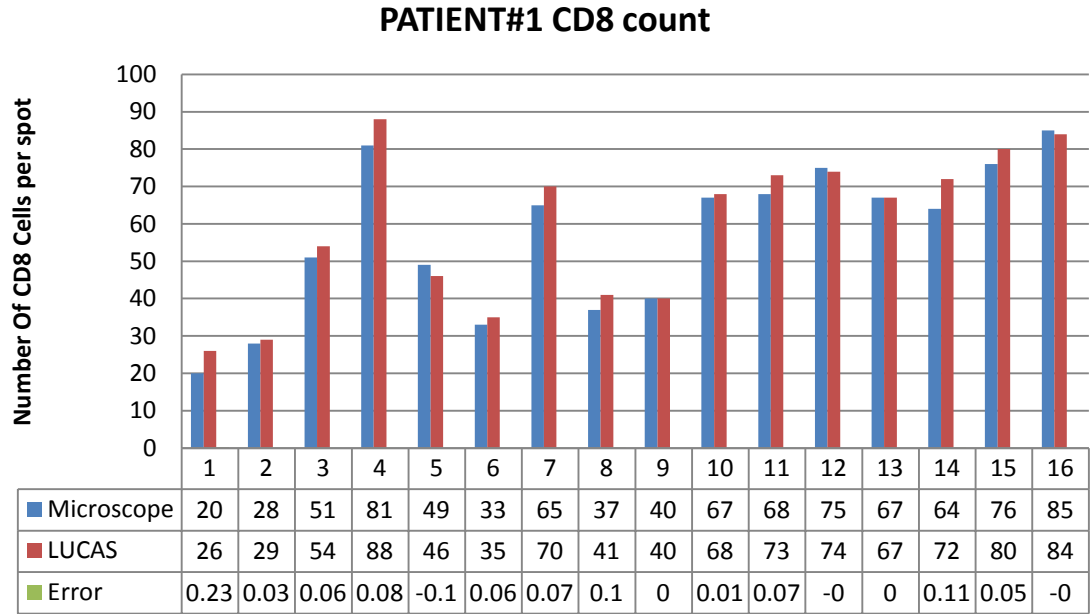


Collaborator: Revzin Group UC Davis

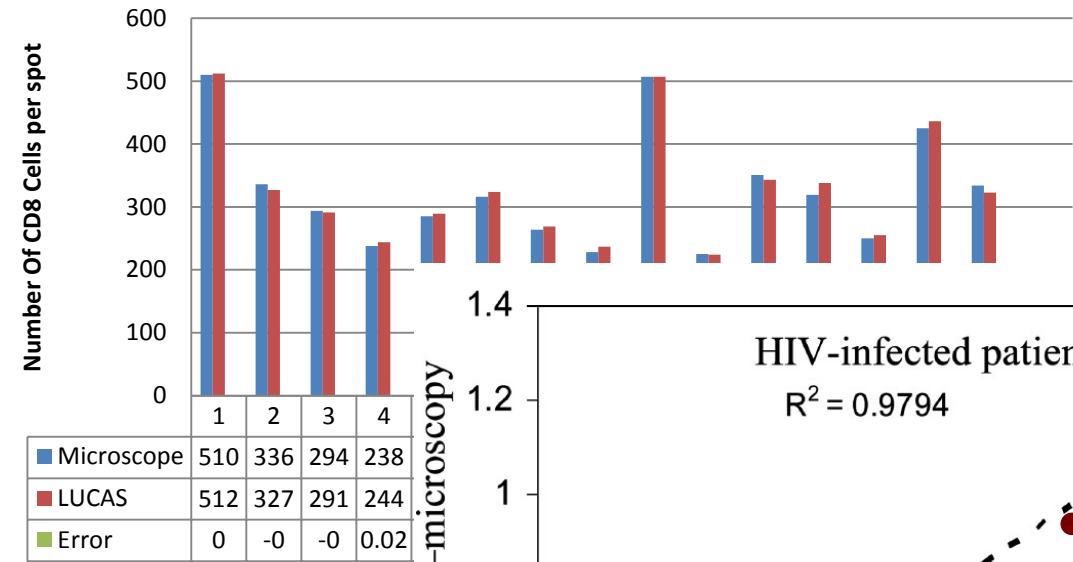


Cell counting in microfluidic channels based on LUCAS

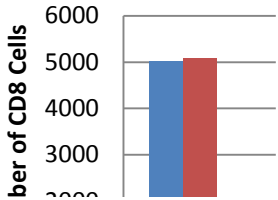




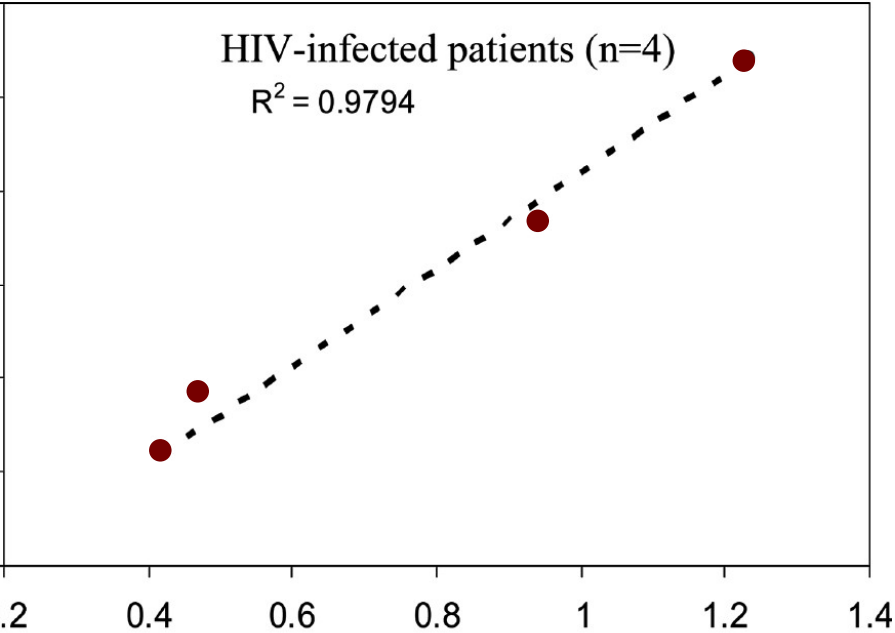
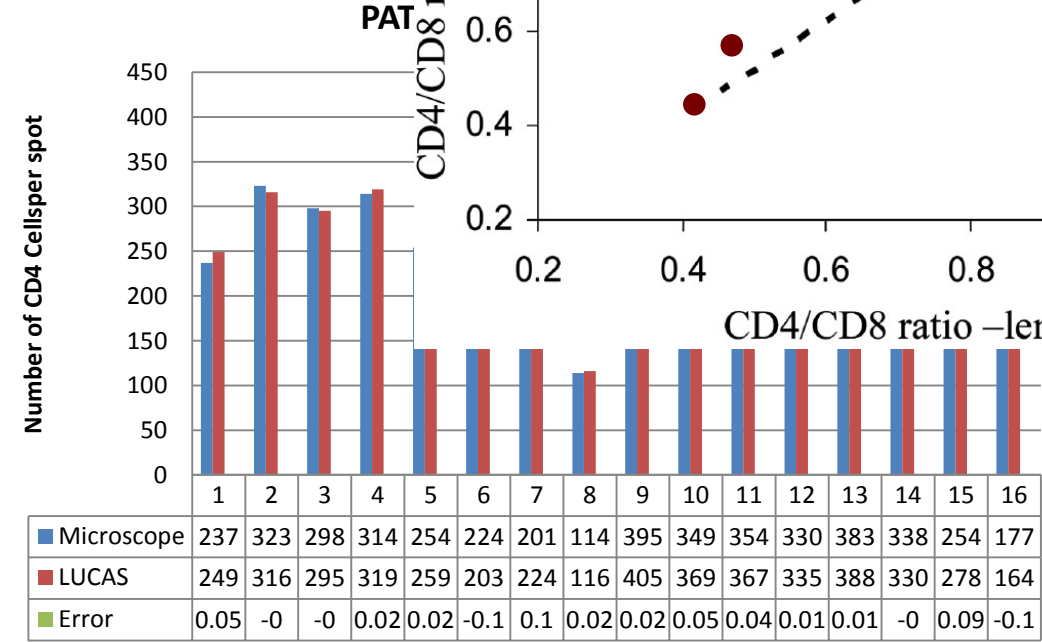
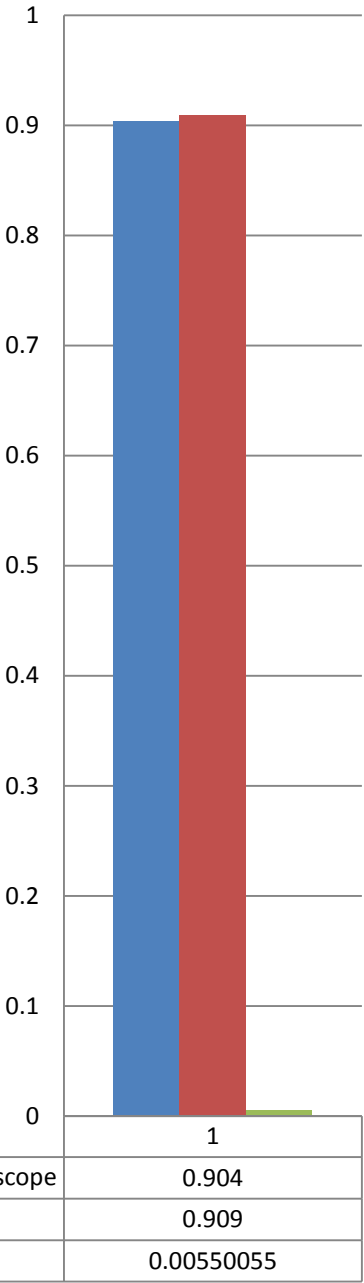
PATIENT#2 CD8 count



Total CD8 Cells

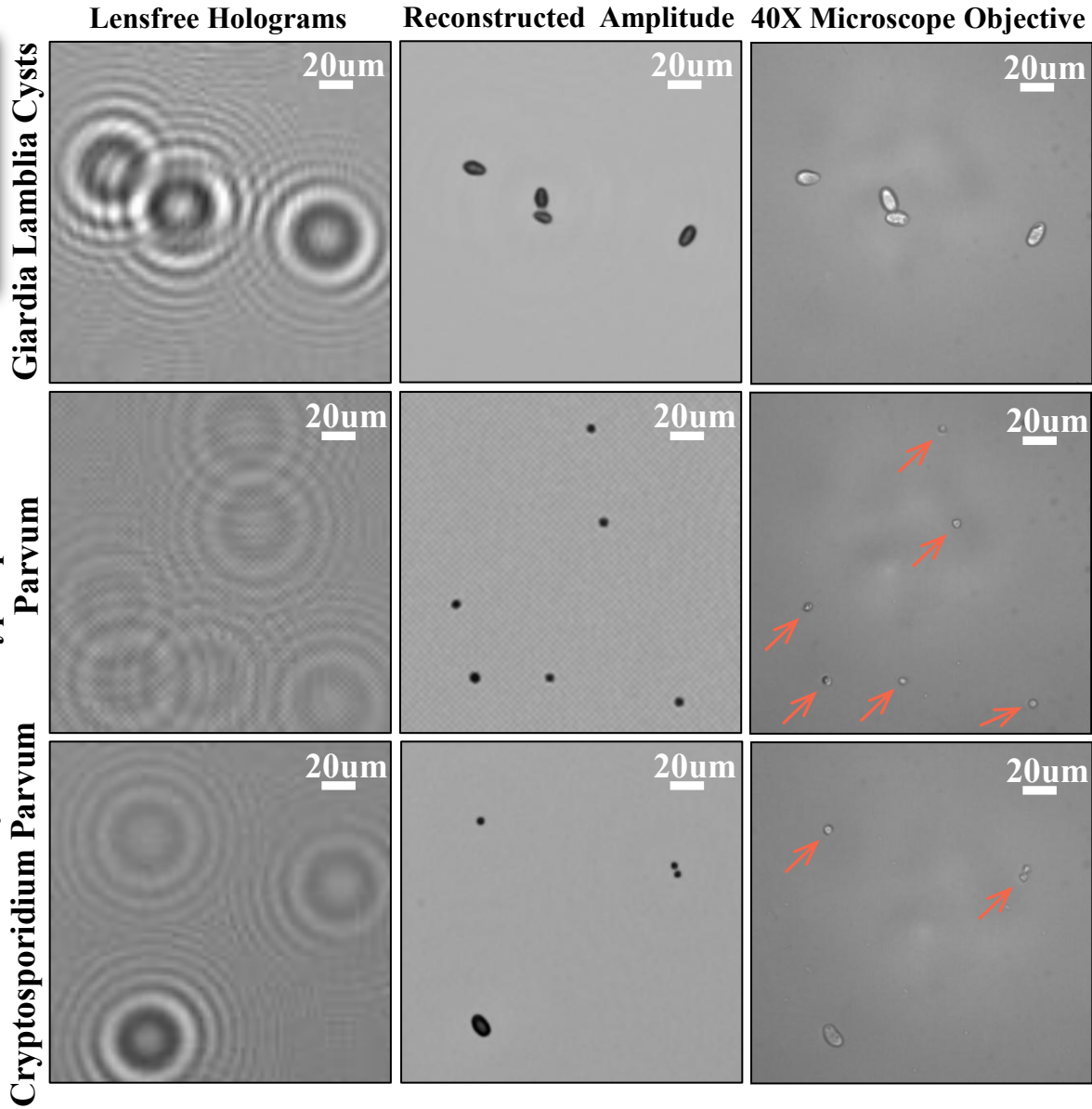
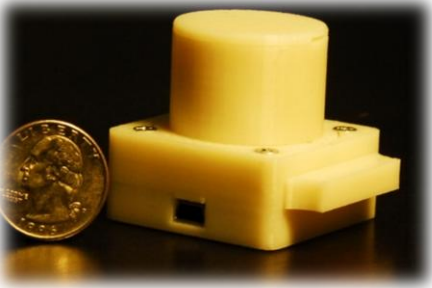


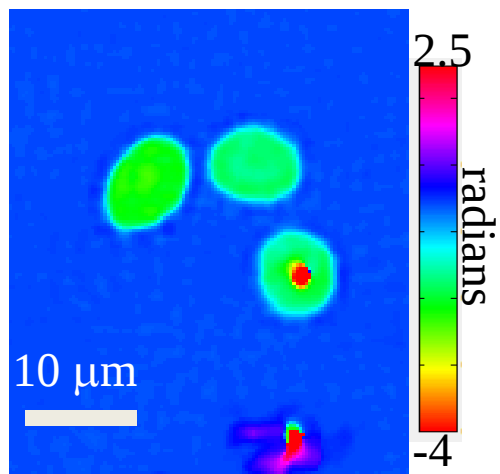
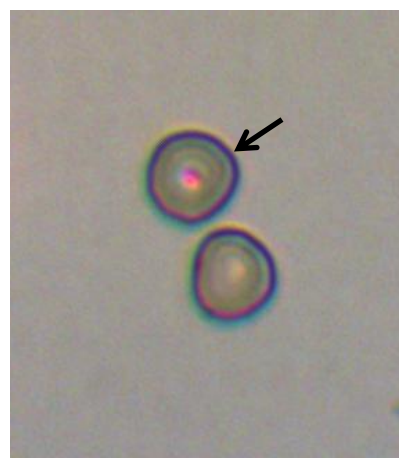
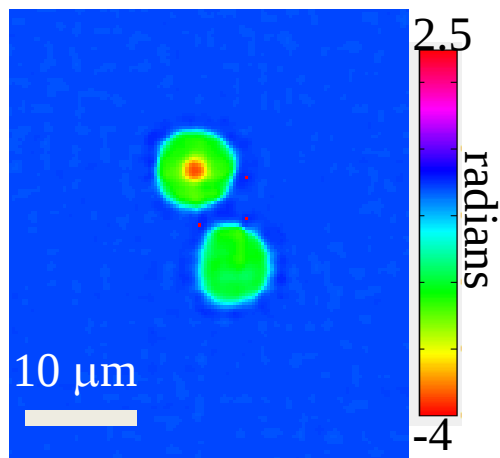
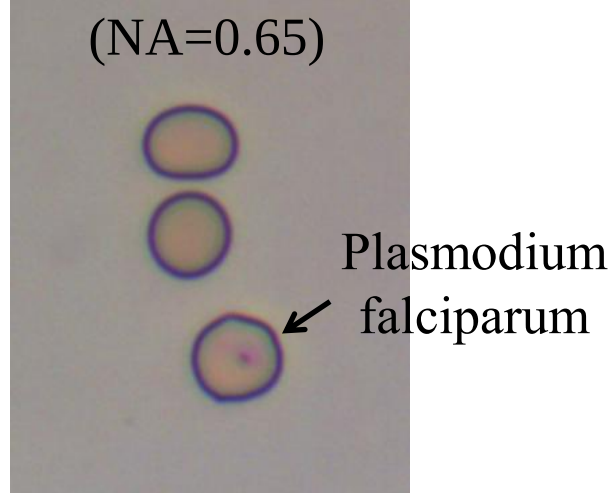
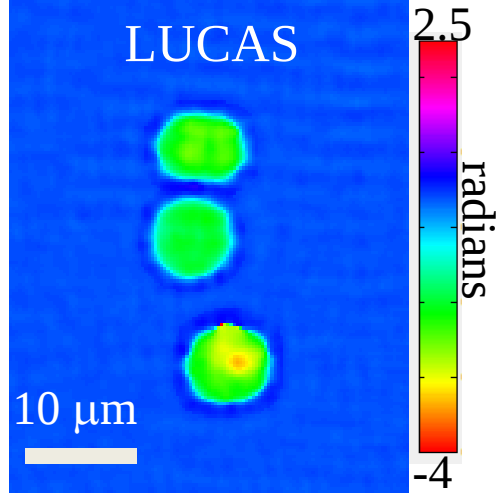
CD4/CD8

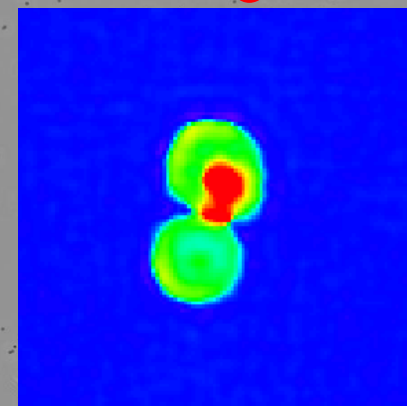
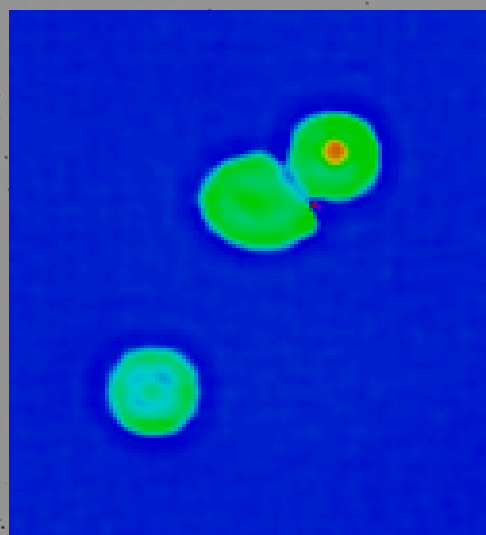
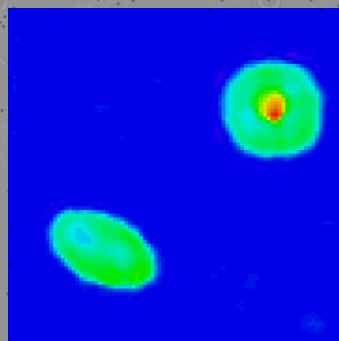




Lensfree Imaging of Waterborne Parasites

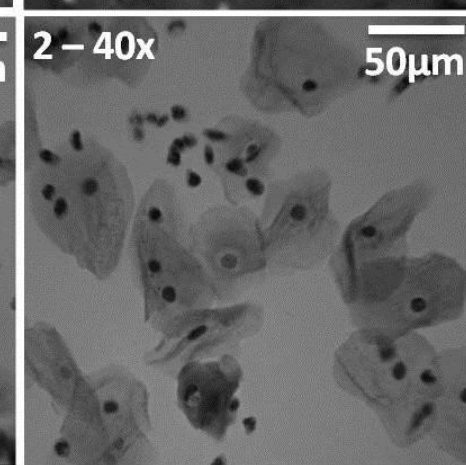
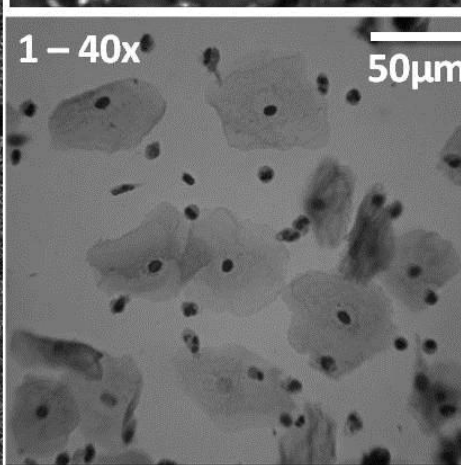
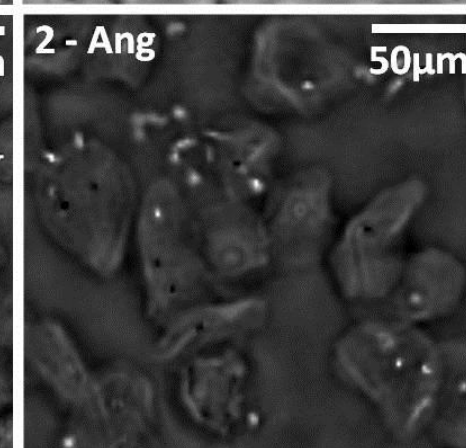
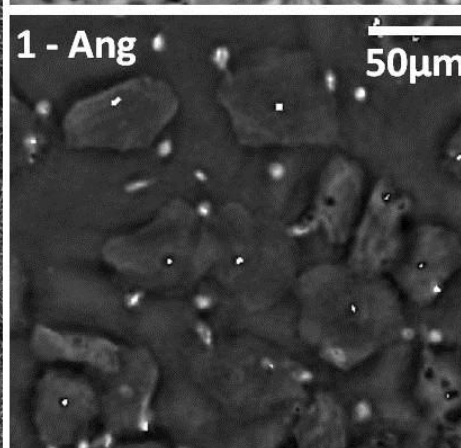
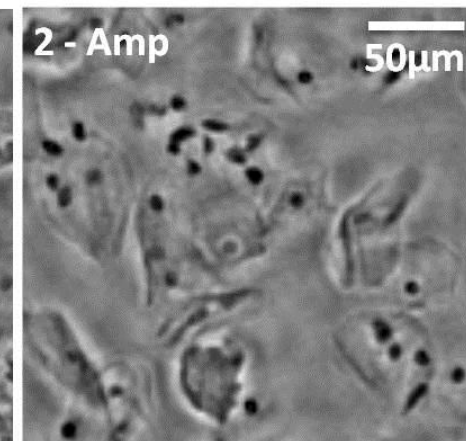
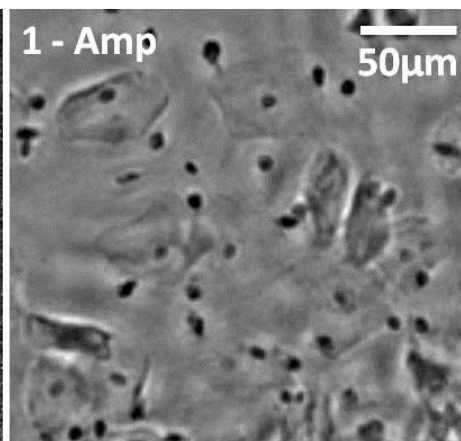
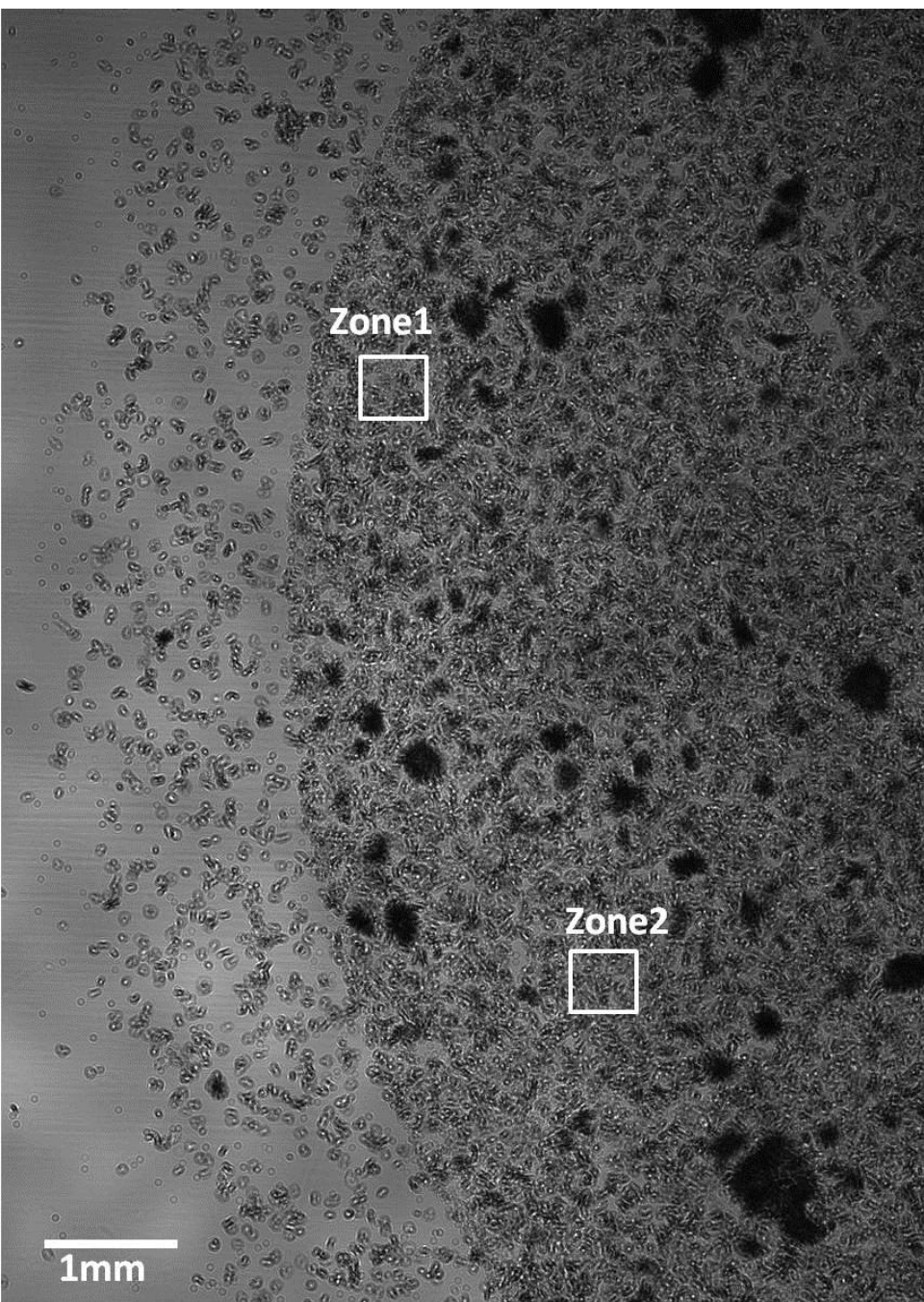






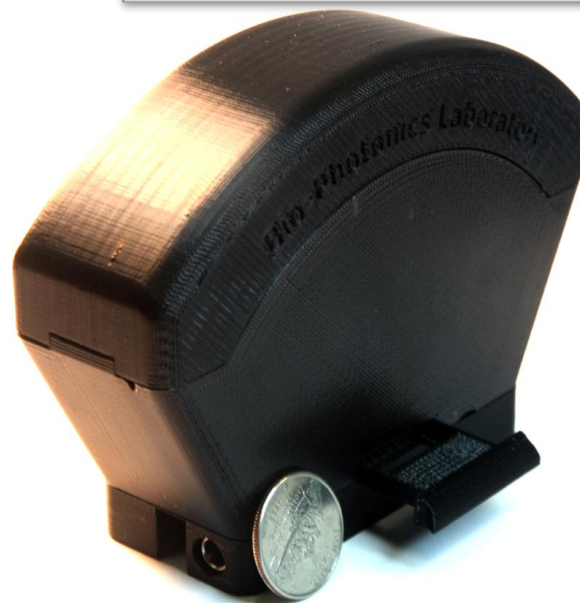
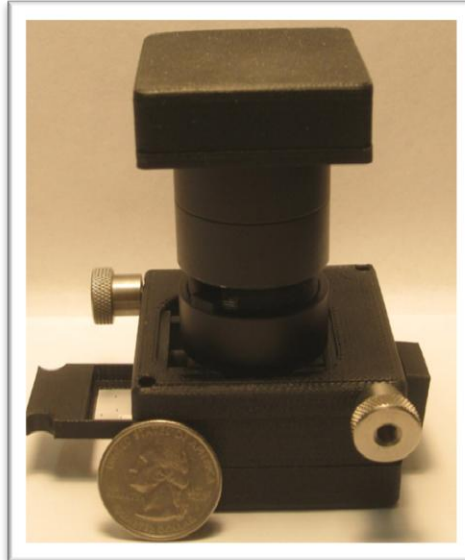
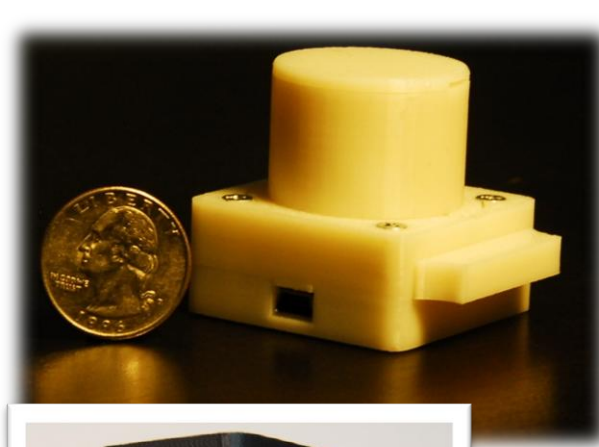
1mm



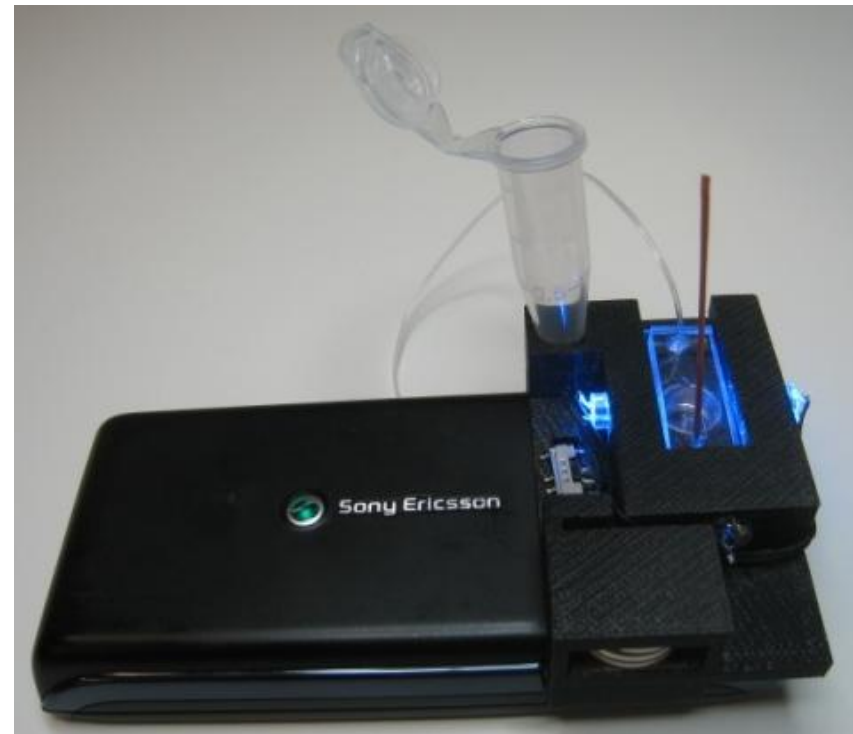
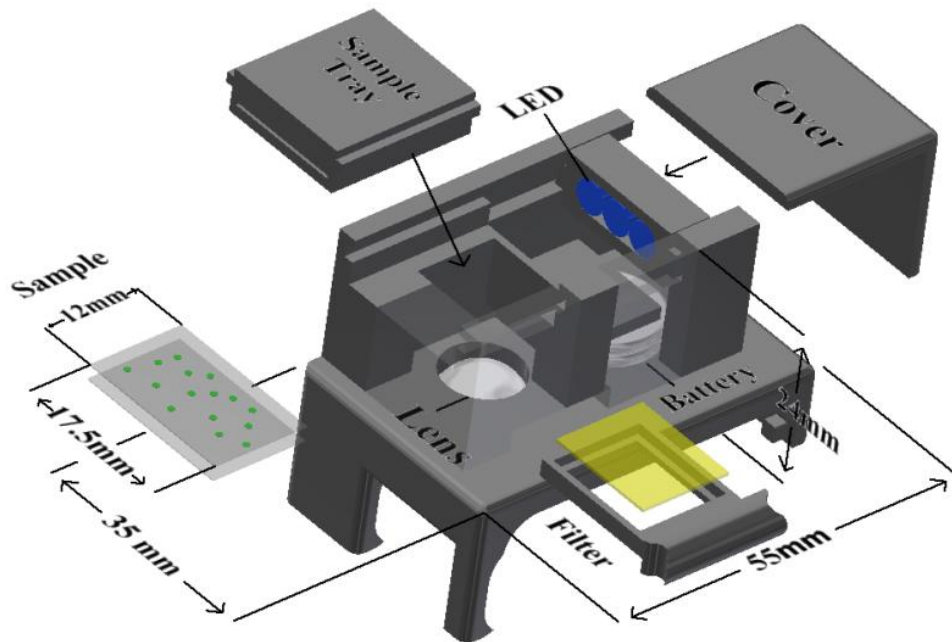




Providing a new platform for telemedicine



Wide-field Fluorescent Microscopy on a Cell-phone



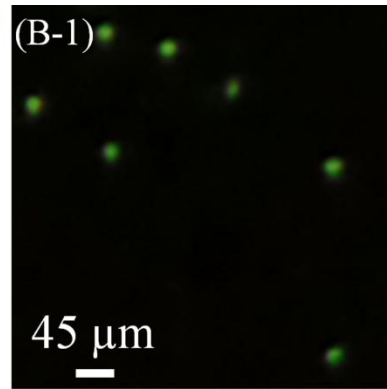
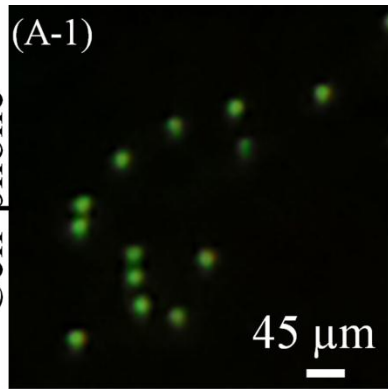


Wide field fluorescent imaging on a cellphone

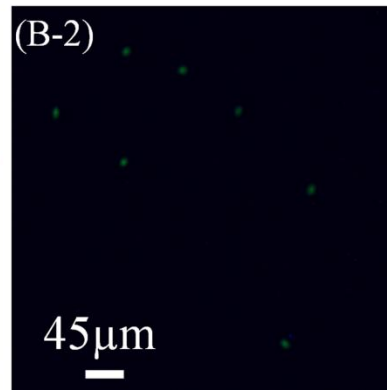
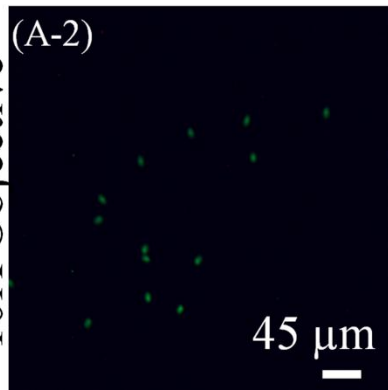


Giardia Lamblia

Cell-phone

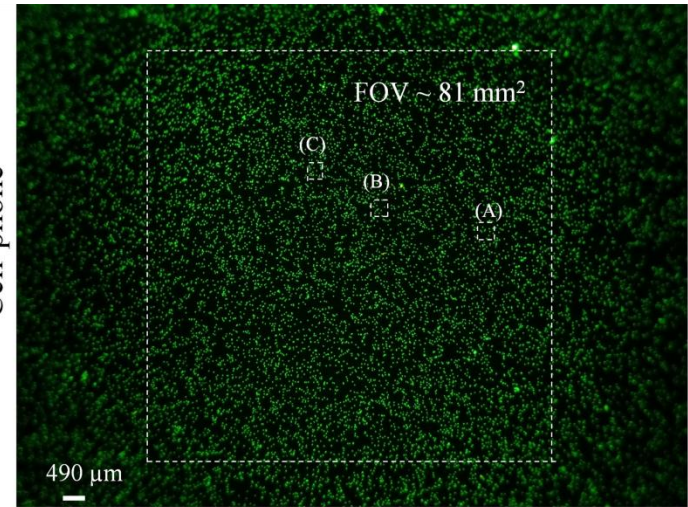


10X Objective



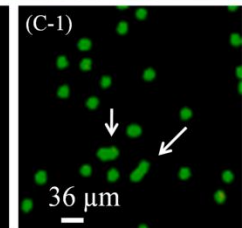
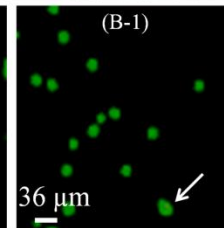
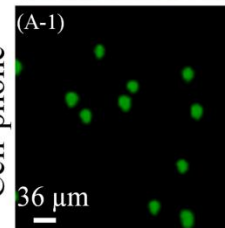
White Blood Cells

Cell-phone

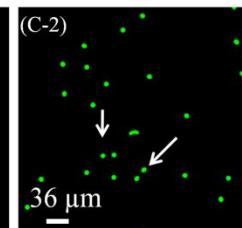
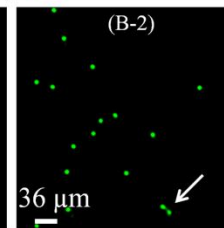
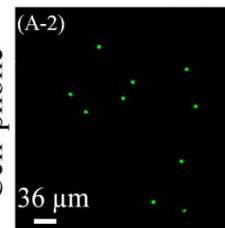


Compressive Decoding

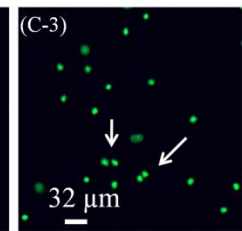
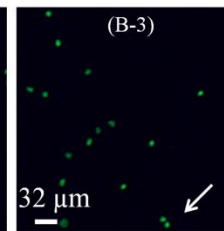
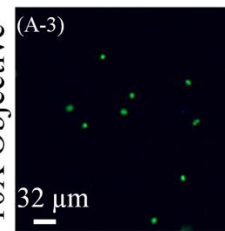
Cell-phone

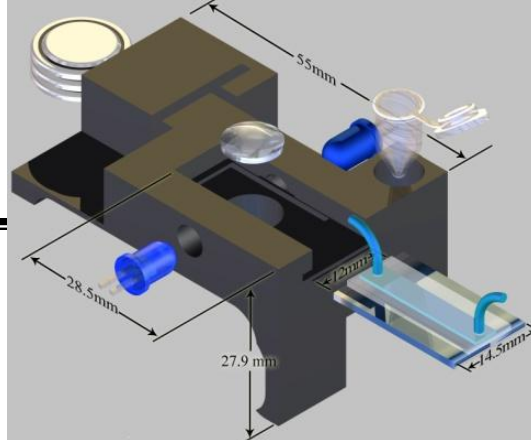


Cell-phone



10X Objective





```
cumulative p/f: 0.00000  
7 frame avg p/f: 0.00  
Total # of cells 0  
Frame # 501  
Time: 0.14s @ 7 FPS  
cumulative p/s: 0.0  
7 frame avg p/s: 0.0
```

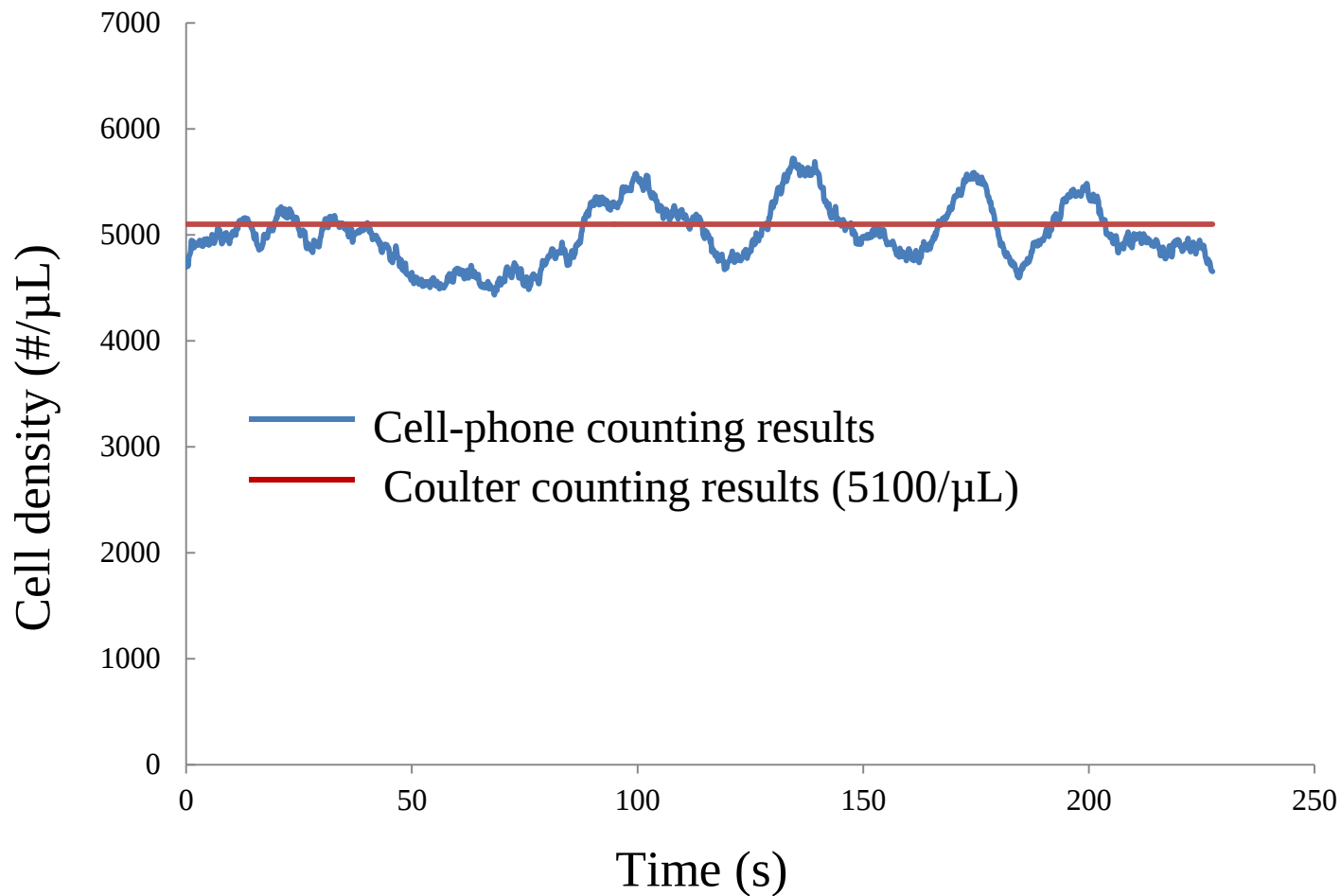
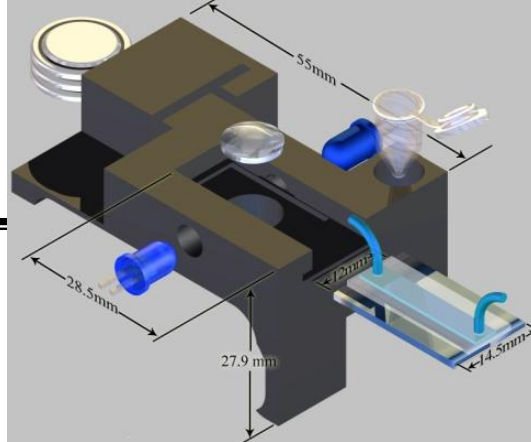
```
Total # of cells thru 0: 1  
7 frame avg p/s: 0.0 (0 cells)  
avg velocity of last 0 cells: -1.0 px/s
```

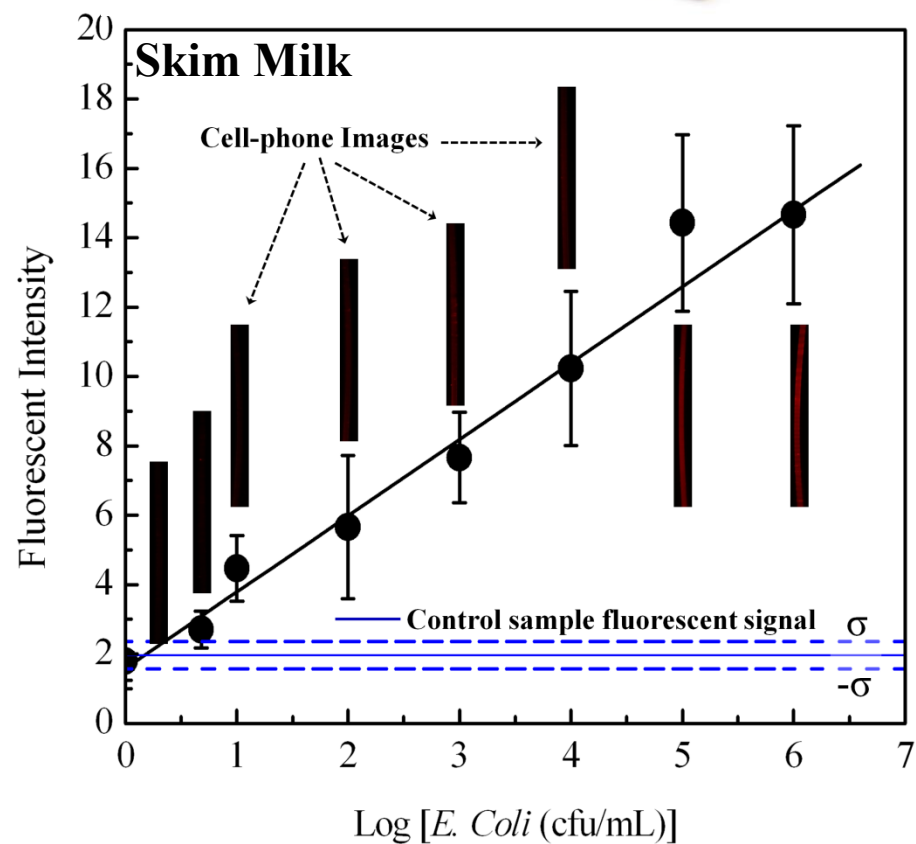
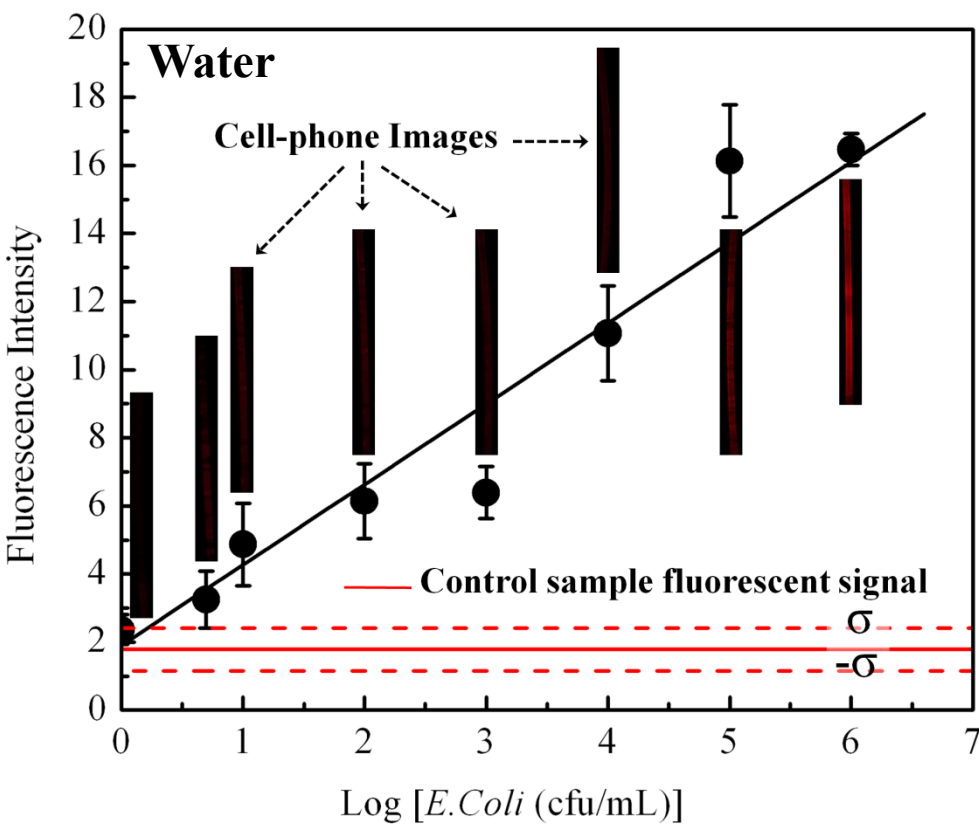
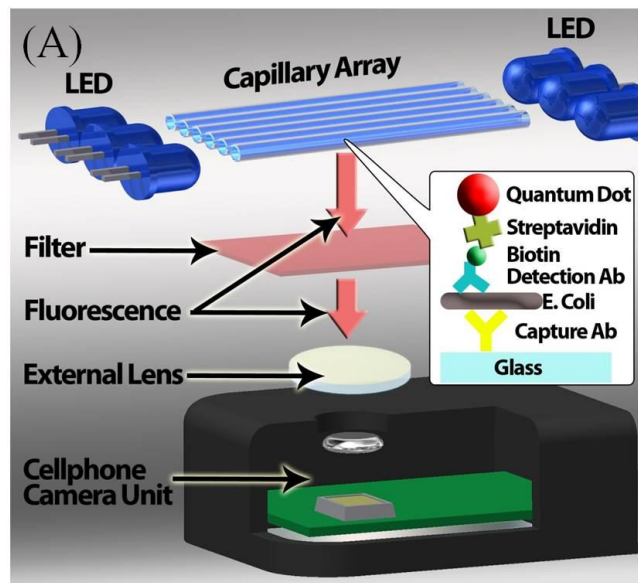
```
Total # of cells thru 1: 0  
7 frame avg p/s: 0.0 (0 cells)  
avg velocity of last 0 cells: -1.0 px/s
```

```
Total # of cells thru 2: 0  
7 frame avg p/s: 0.0 (0 cells)  
avg velocity of last 0 cells: -1.0 px/s
```

```
Total # of cells thru 3: 0  
7 frame avg p/s: 0.0 (0 cells)  
avg velocity of last 0 cells: -1.0 px/s
```

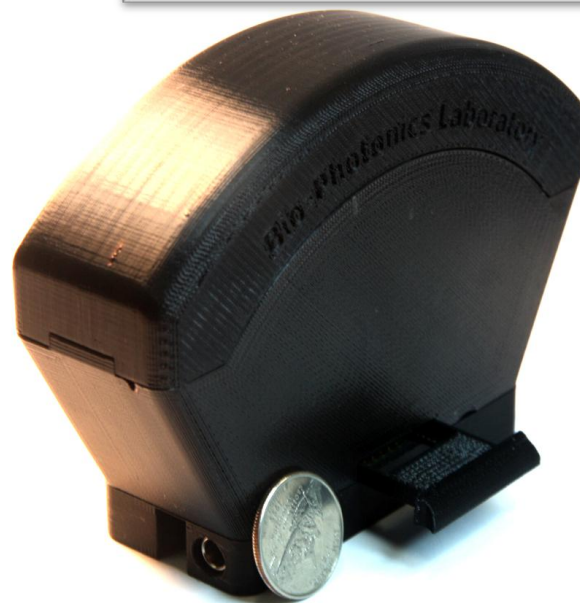
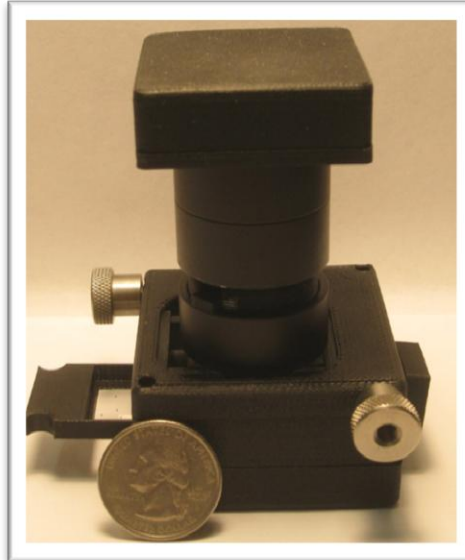
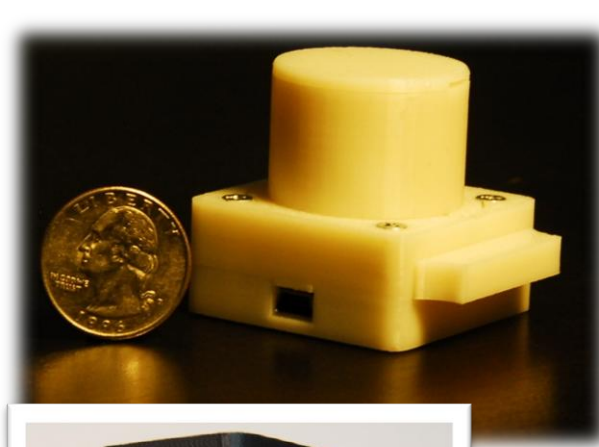
```
Total # of cells thru 4: 0  
7 frame avg p/s: 0.0 (0 cells)
```







Providing a new platform for telemedicine

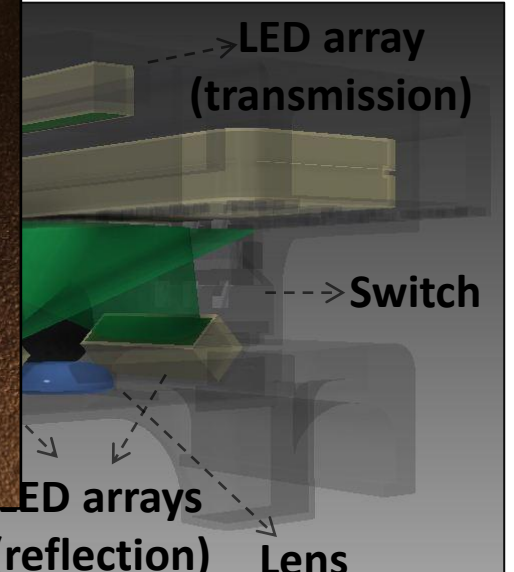
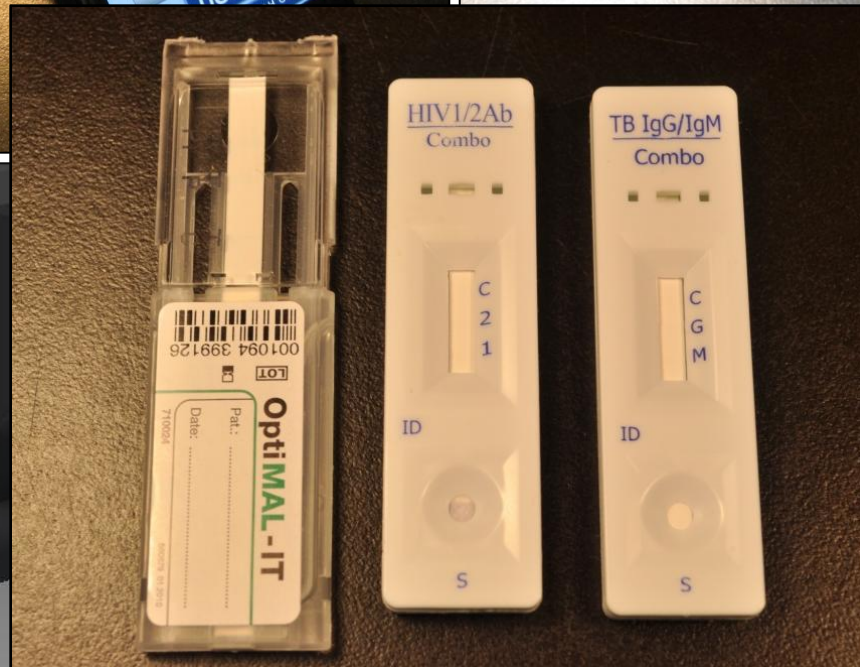
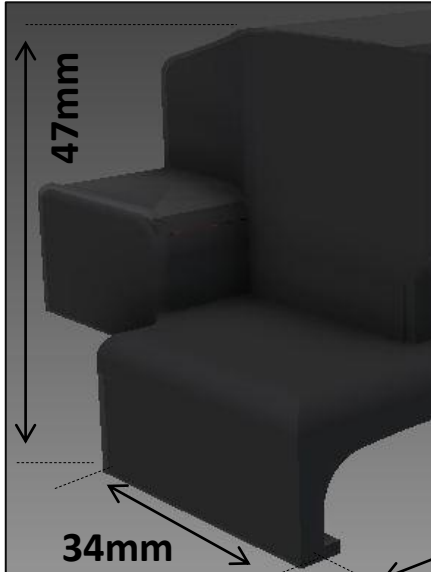




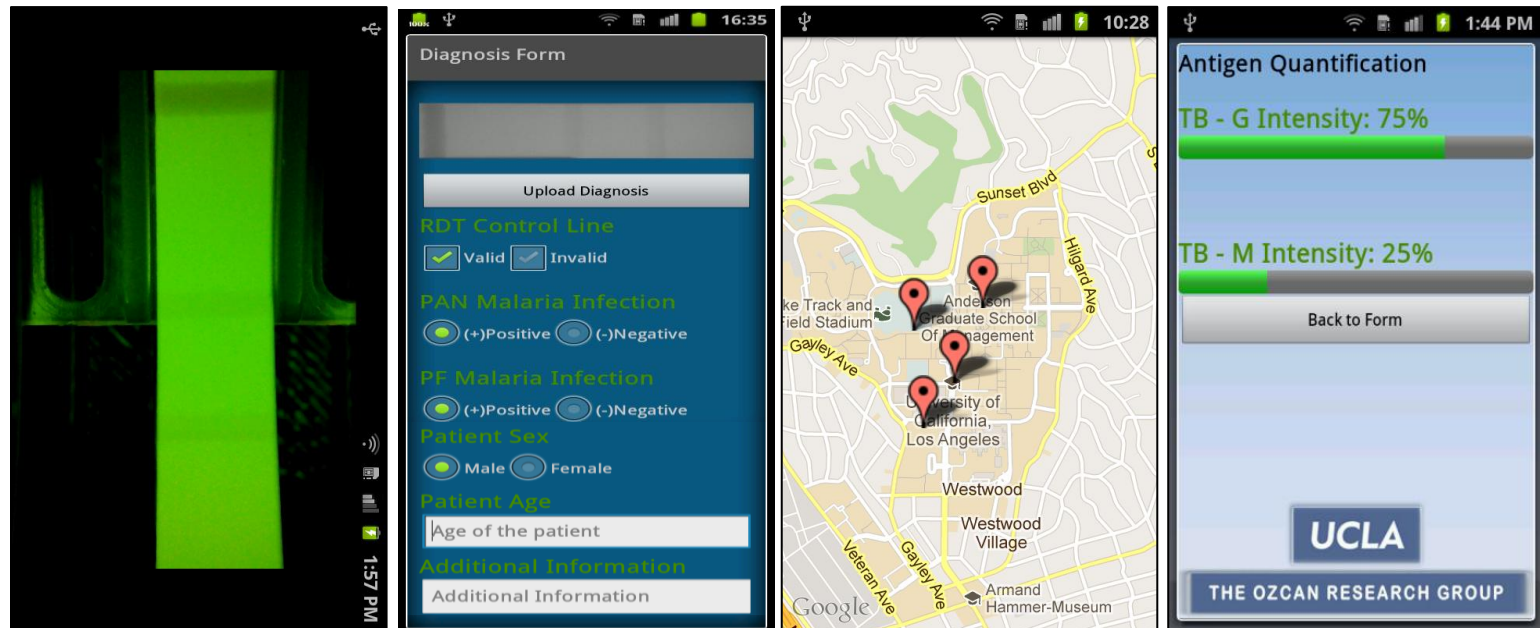
Digital Diagnosis



Integrated Rapid-Diagnostic-Test Reader Platform on a Cellphone



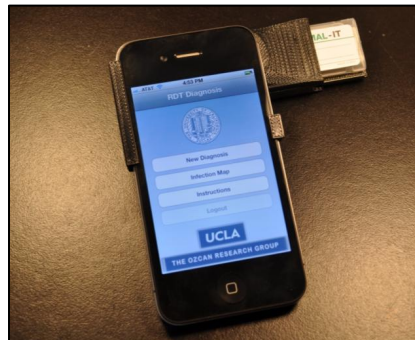
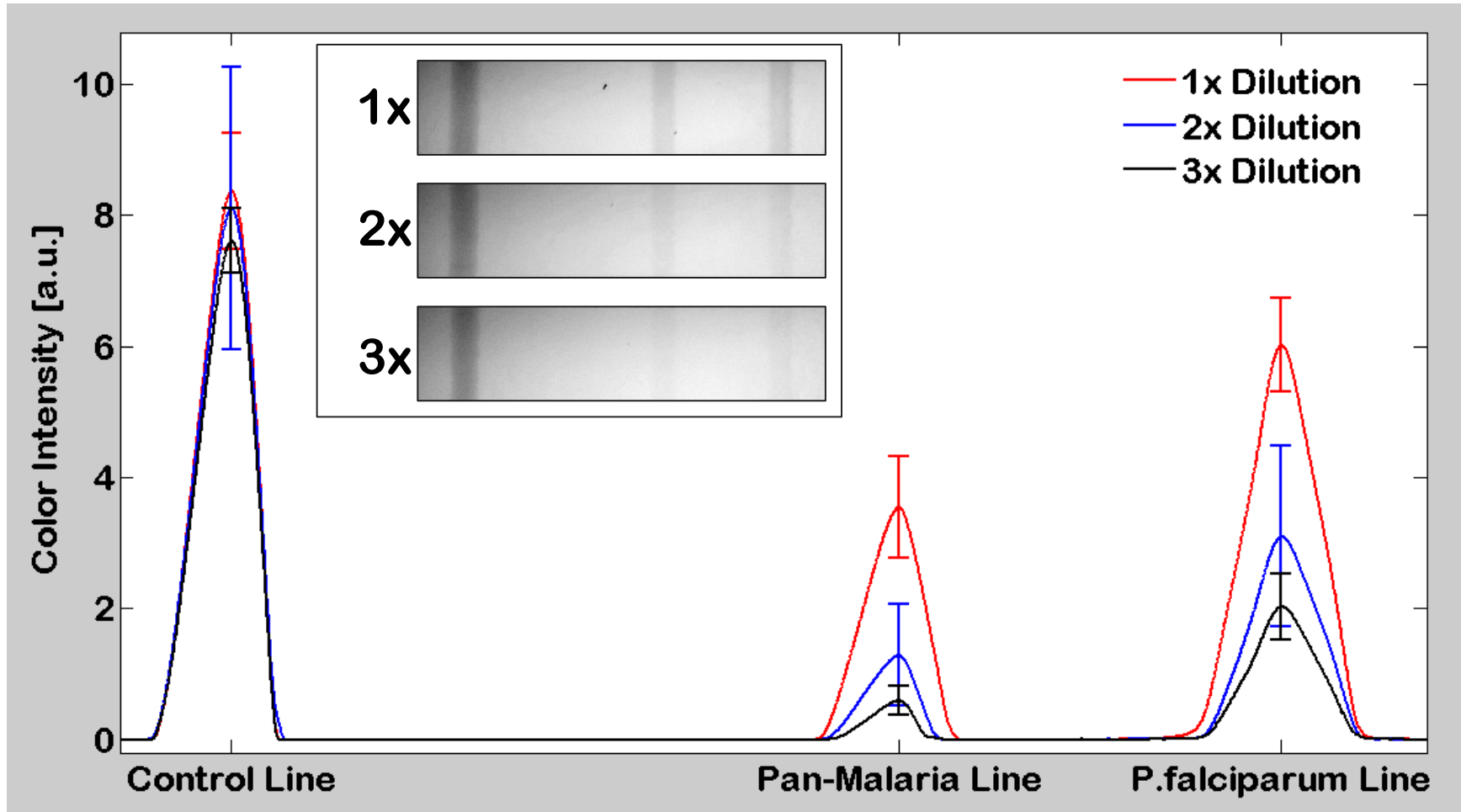
Integrated Rapid-Diagnostic-Test Reader Platform on a Cellphone



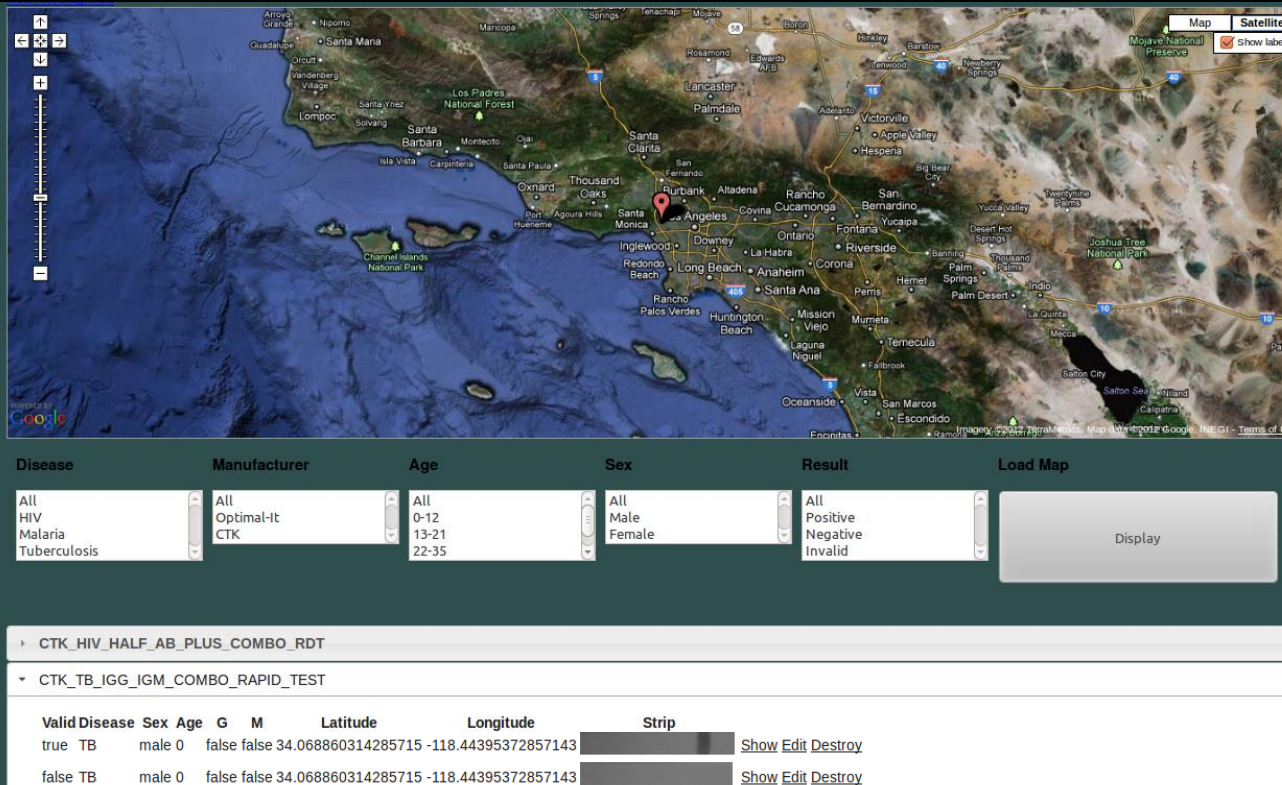
Integrated Rapid-Diagnostic-Test Reader Platform on a Cellphone



Integrated Rapid-Diagnostic-Test Reader Platform on a Cellphone



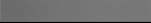
Integrated Rapid-Diagnostic-Test Reader Platform on a Cellphone

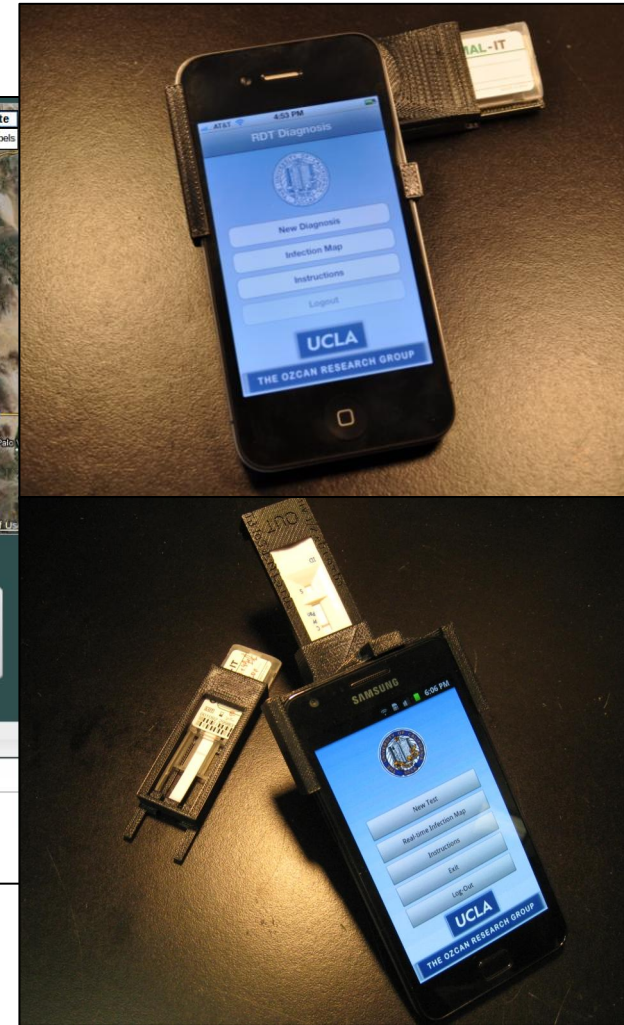


Disease	Manufacturer	Age	Sex	Result	Load Map
All HIV Malaria Tuberculosis	All Optimal-It CTK	All 0-12 13-21 22-35	All Male Female	All Positive Negative Invalid	Display

CTK_HIV_HALF_AB_PLUS_COMBO_RDT

CTK_TB_IGG_IGM_COMBO_RAPID_TEST

Valid Disease	Sex	Age	G	M	Latitude	Longitude	Strip	
true	TB	male	0	false	false	34.068860314285715	-118.44395372857143	 Show Edit Destroy
false	TB	male	0	false	false	34.068860314285715	-118.44395372857143	 Show Edit Destroy





An Analogy: From PCs to the Internet





The μ -Internet





Diagnosis of Malaria using Crowd-Sourced Games



<http://biogames.ee.ucla.edu/>



Diagnosis of Malaria using Crowd-Sourced Games



**More than 70 countries are playing BioGames, with
~1.5 Million cell diagnoses so far.**



Ozcan Research Group – Members & Funding

