# Plankton's Role in a Healthy Aquaponics System

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# User Interface

## *"Where the bits meet the flesh"*


VR PowerGlove

PAN

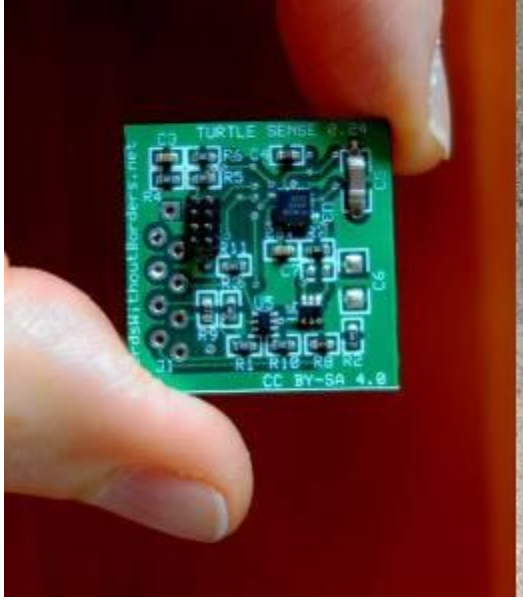

Medical Monitoring

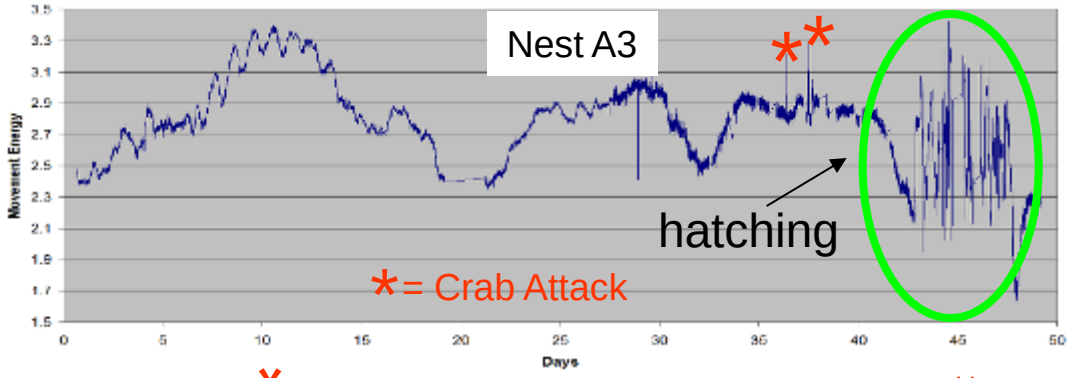
Pen Input Devices

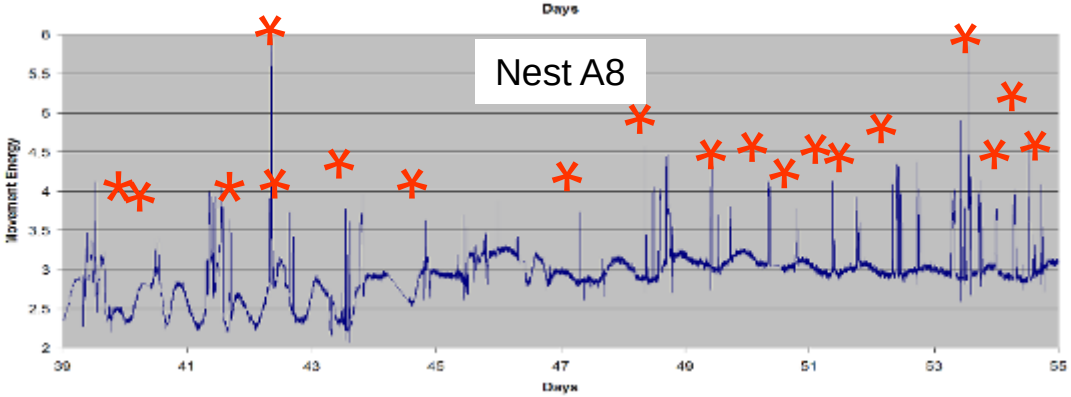
Self Check-In PDA

Biometric PDA

# Turtle Sense




http://nerdswithoutborders.net

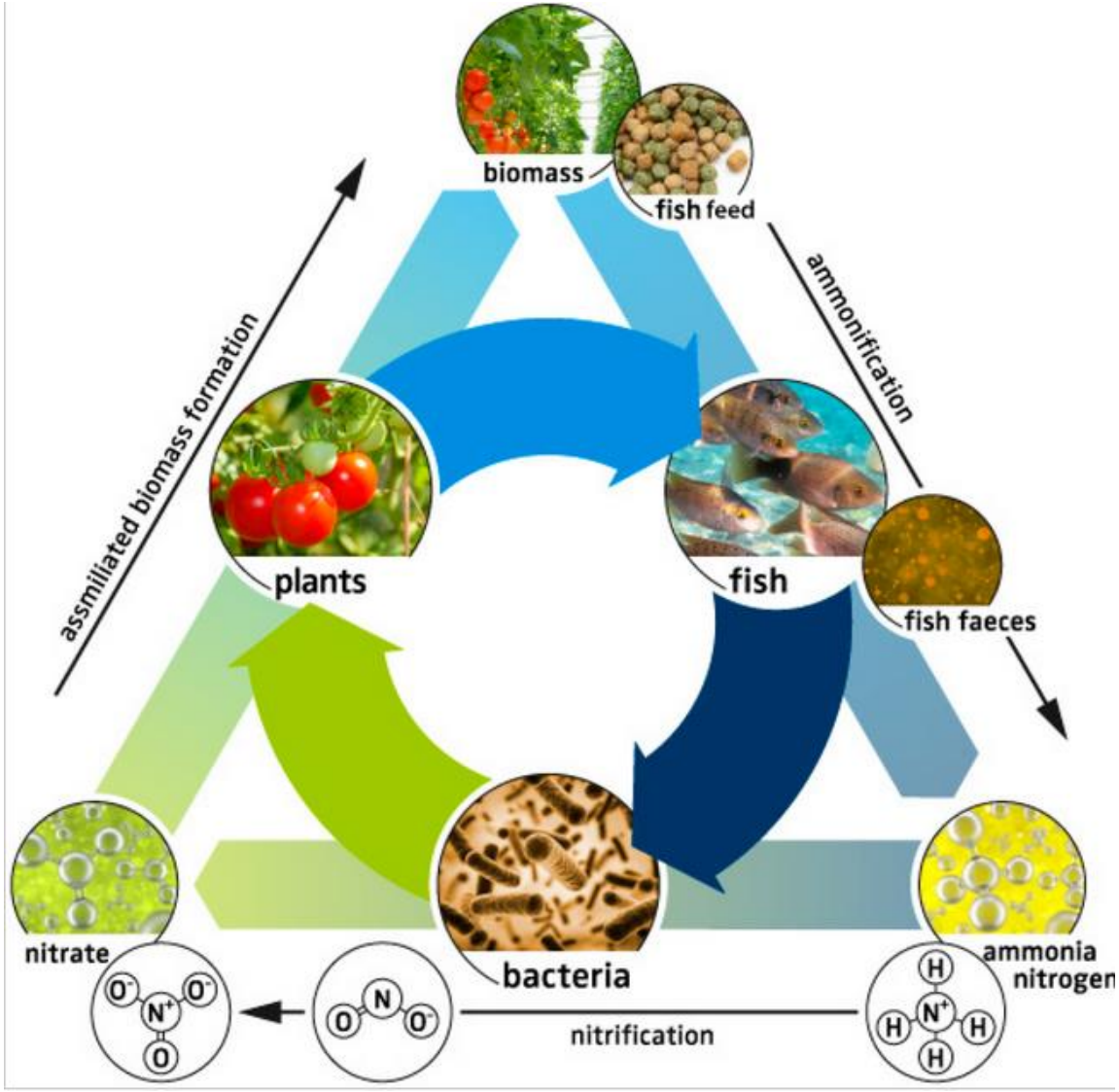
# Aquaponics Monitoring System

***Plankton is the canary in a coal mine; an early indicator of potential danger or failure.***

Require; Power (5 v @ 0.25 amp or AC power), WiFi

https://aquaponics.com/store2/f5-aquaponic-systems-essentials-package/
https://sustainabilityactive.com/2018/03/smartphones-data-centers-harm-environment-study-shows/

# Aquaponics Food Cycle

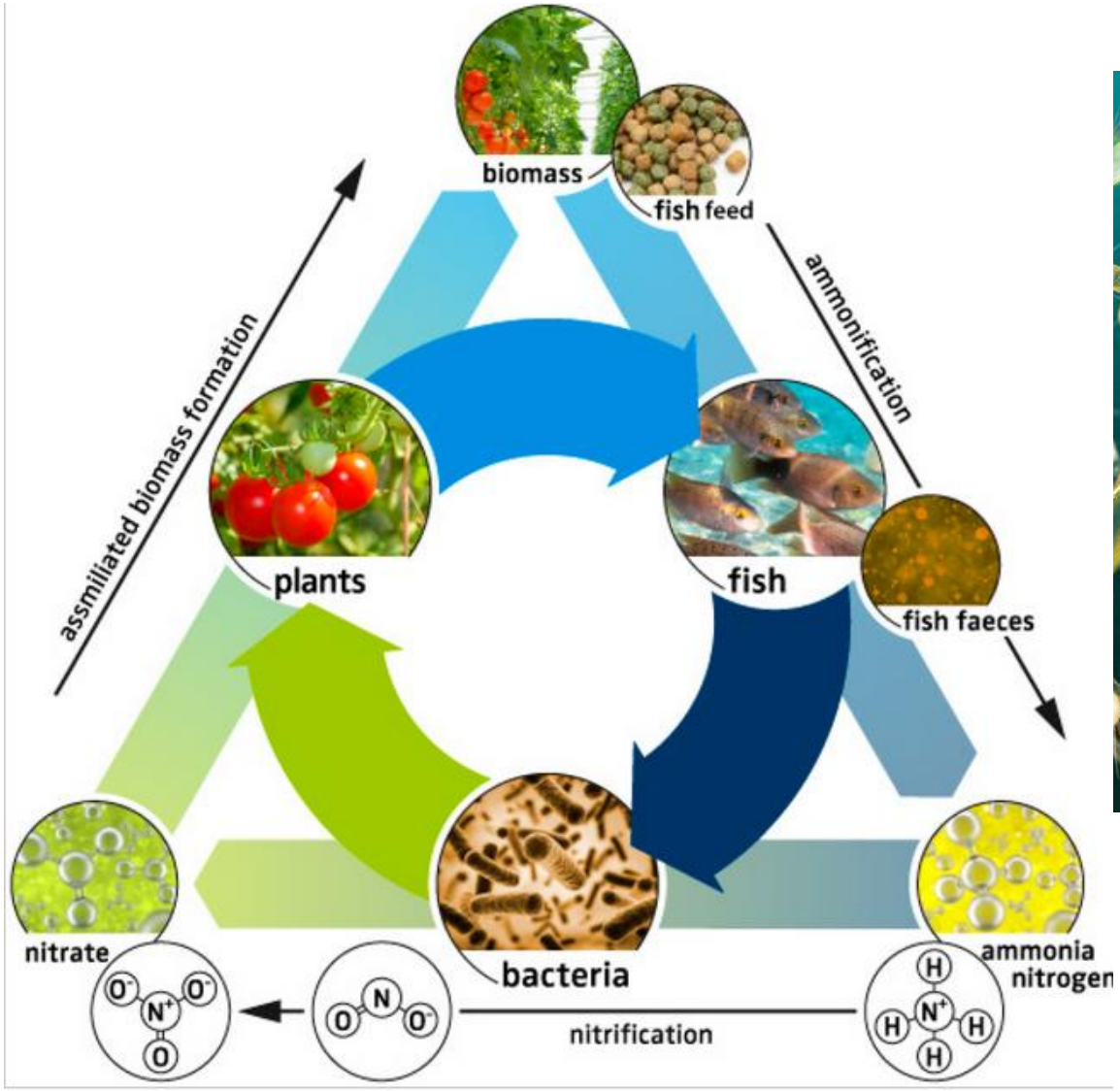



NH3

NH4

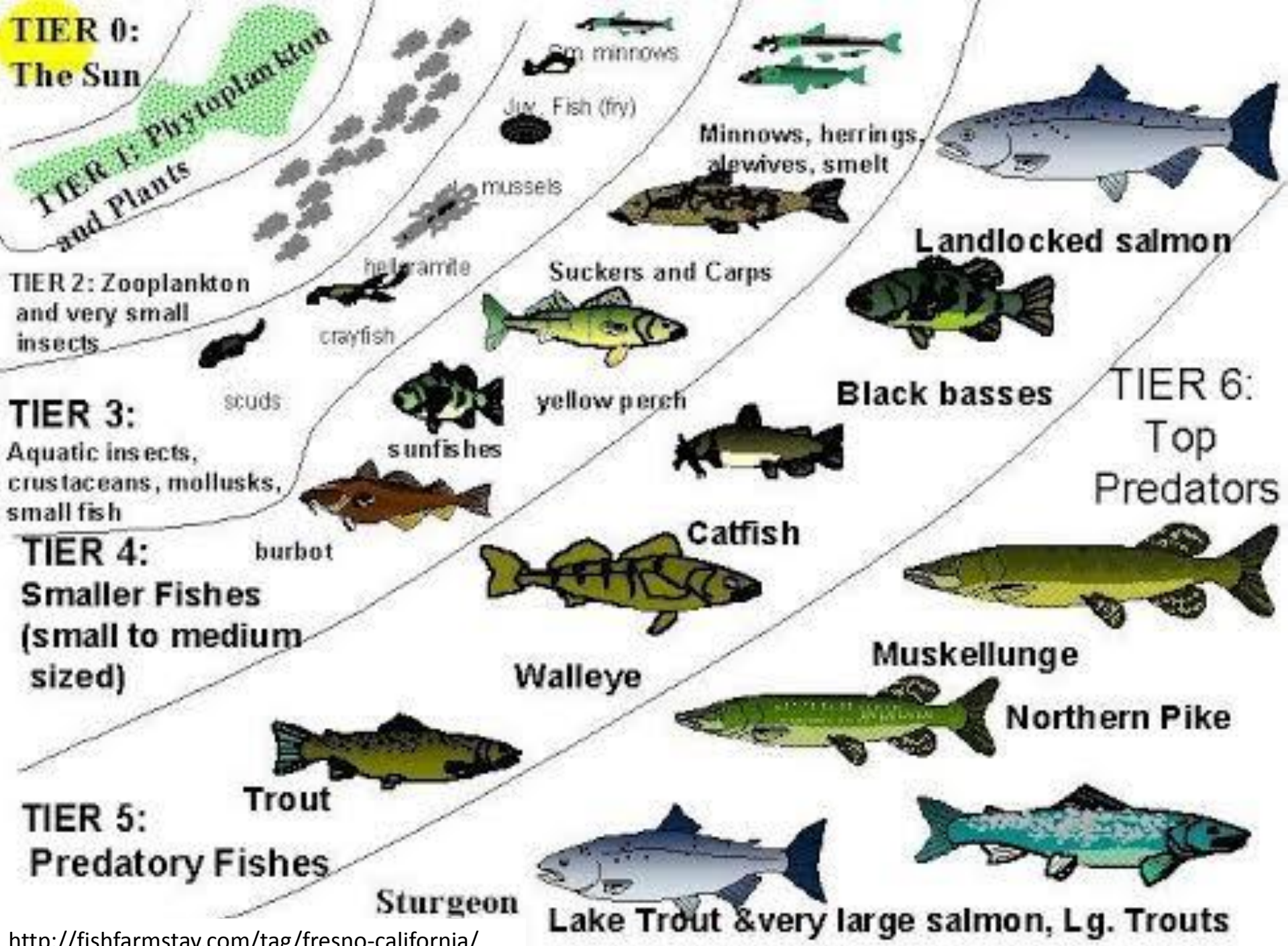
http://www.mdpi.com/2071-1050/7/4/4199/htm /

# Aquaponics Food Cycle




Plankton !

http://www.mdpi.com/2071-1050/7/4/4199/htm
http://blueplanetsociety.org/2015/03/the-importance-of-plankton/




http://fishfarmstay.com/tag/fresno-california/

# Plankton

(planktos, Greek for errant, wanderer or drifter)

*Small and microscopic organisms drifting or floating in the sea or fresh water, consisting chiefly of diatoms, protozoans, small crustaceans, and the eggs and larval stages of larger animals.*

**Two Types of Plankton**

==========

**Phytoplankton**=plant (chlorophyll)

**Zooplankton**=animal

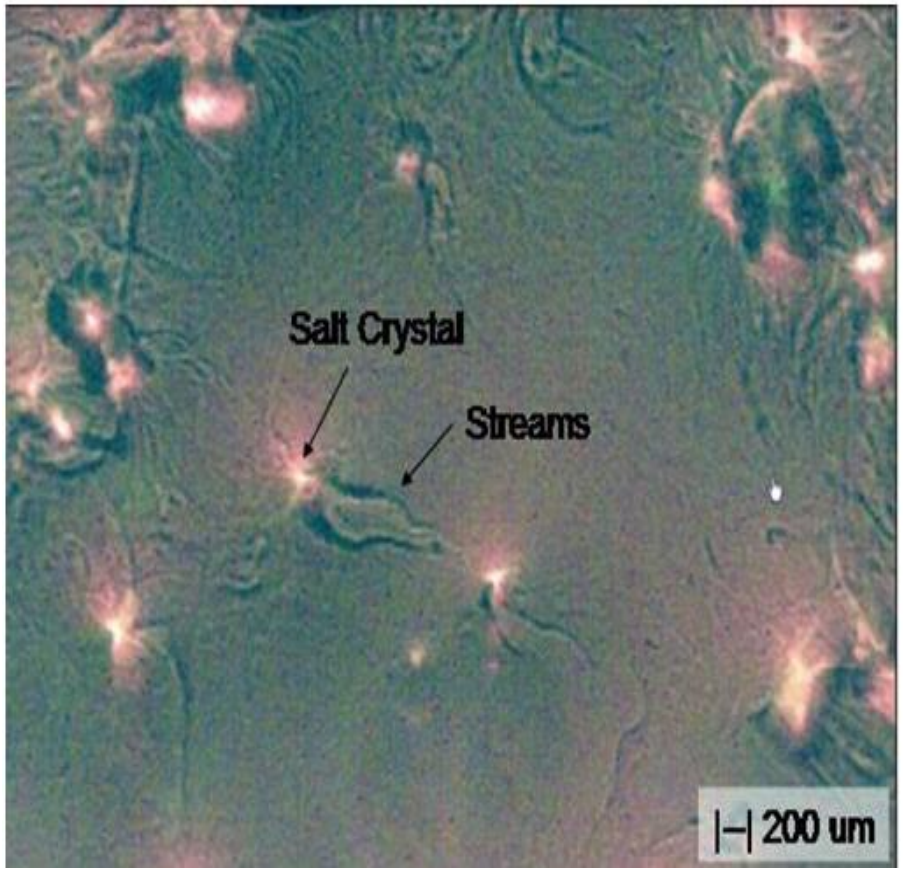
| GROUP | SIZE RANGE | EXAMPLE |
|---|---|---|
| Megaplankton | > 20 cm | jellyfish |
| Macroplankton | 2→20 cm | krill |
| Mesoplankton | **0.2→**20 mm | copepods |
| Microplankton | **20→200 µm** | protozoa, rotifer |
| Nanoplankton | **2→20 µm** | small diatoms |
| Picoplankton | 0.2**→2 µm** | bacteria |
| Femtoplankton | < 0.2 µm | marine viruses |

**Lensless Microscope** 20 um to 2 mm (white LED) , down to 2 um (LASER)

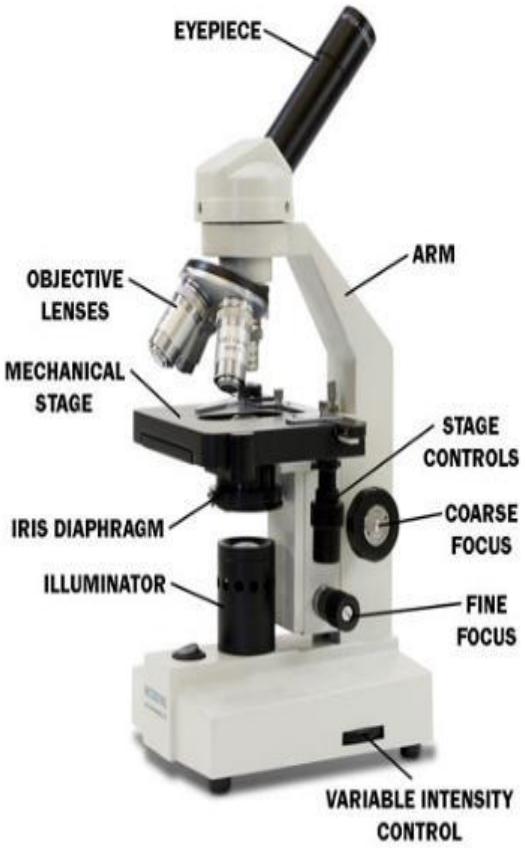
https://en.wikipedia.org/wiki/Plankton

# The Experiment (2007)

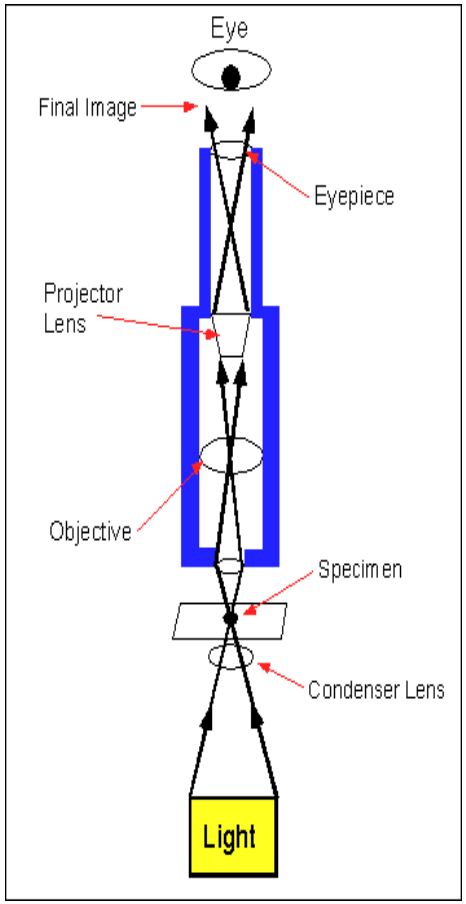

Web Camera (no lens)



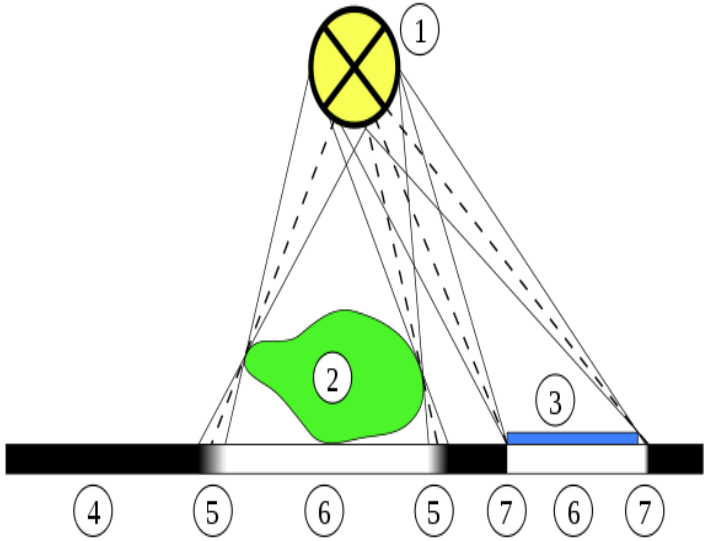
# Conventional Microscope

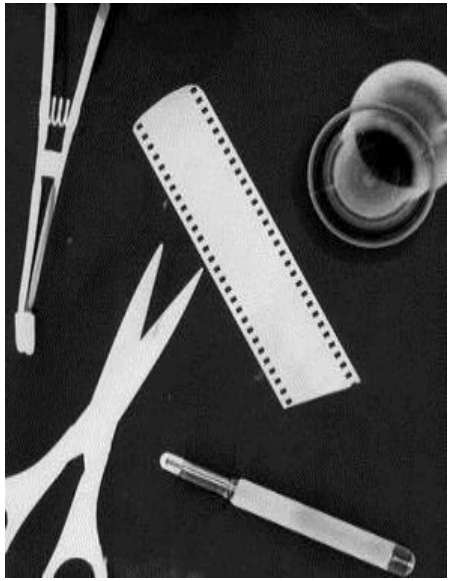


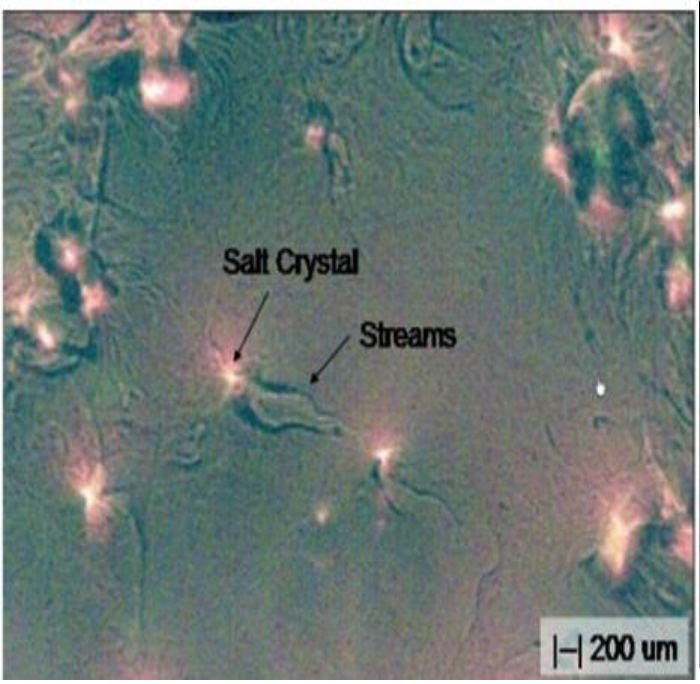

# Microscope Optical Path

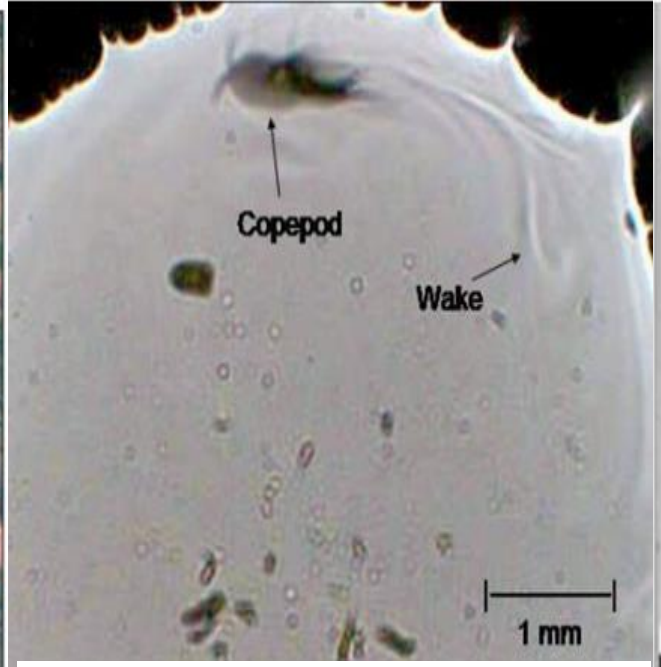


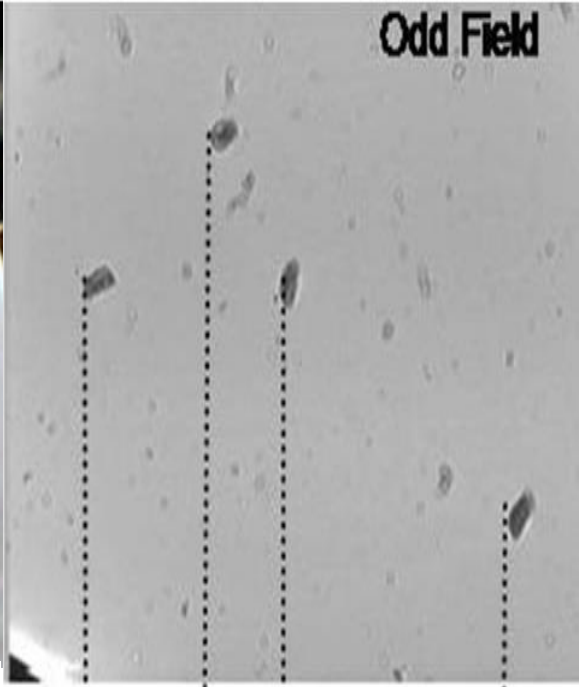

# Photogram "contact sheet"



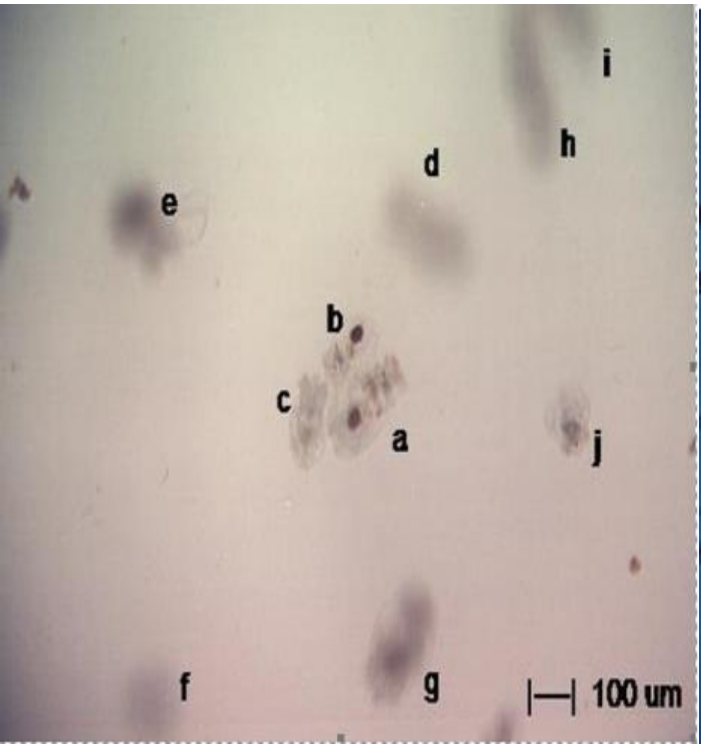



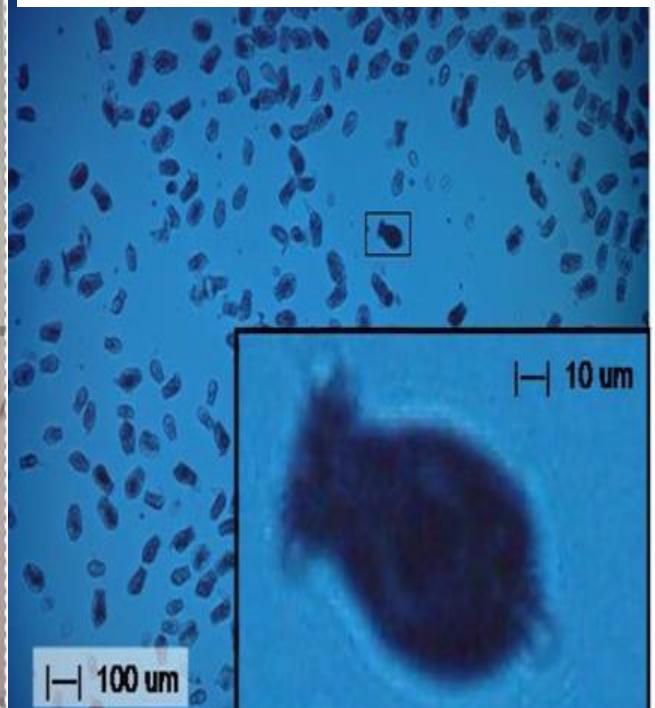


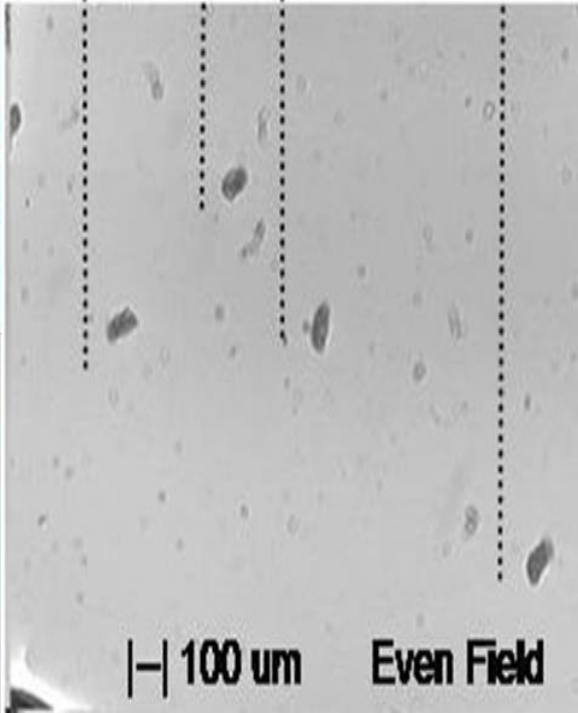



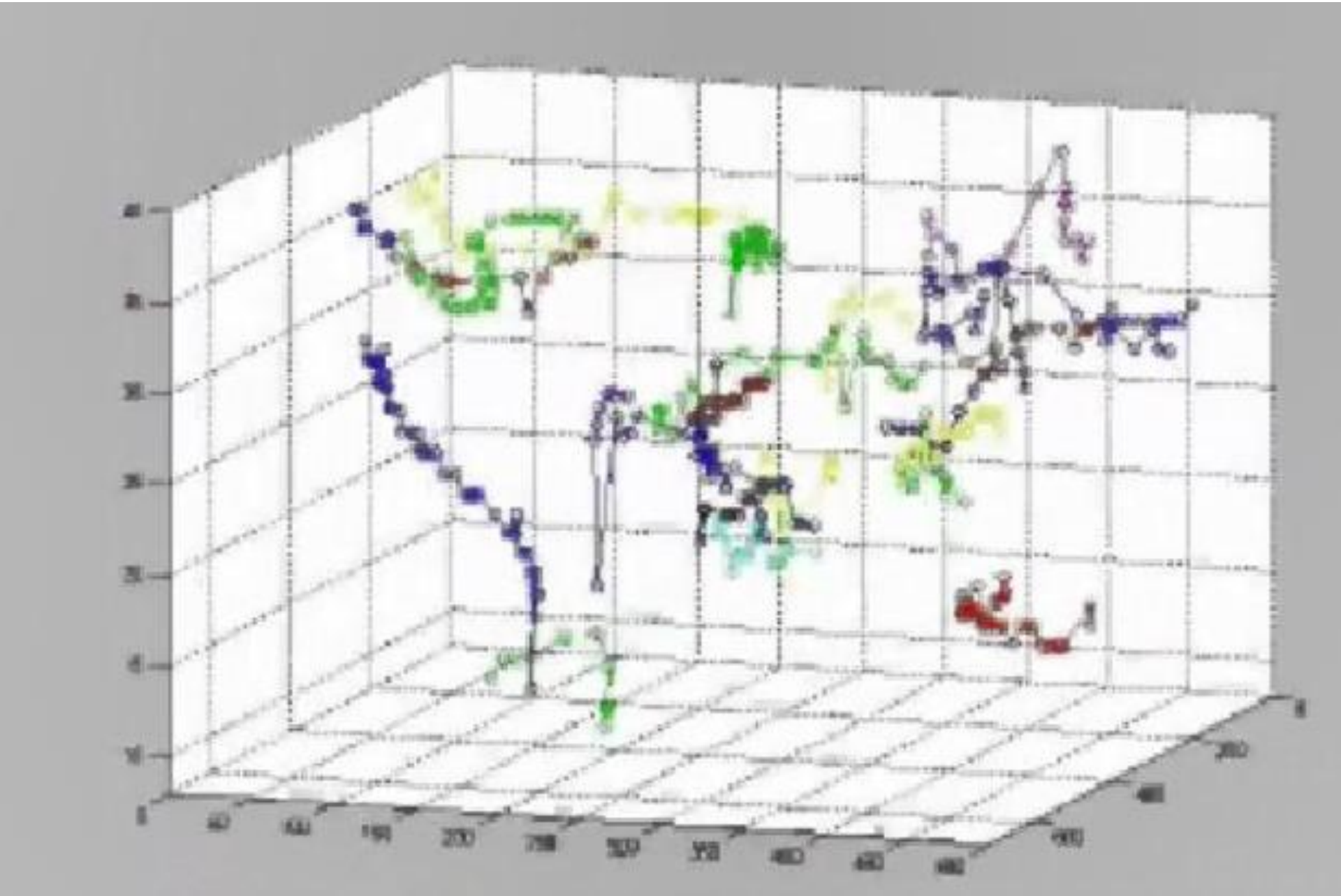

Microzooplankton, 20-200 µm



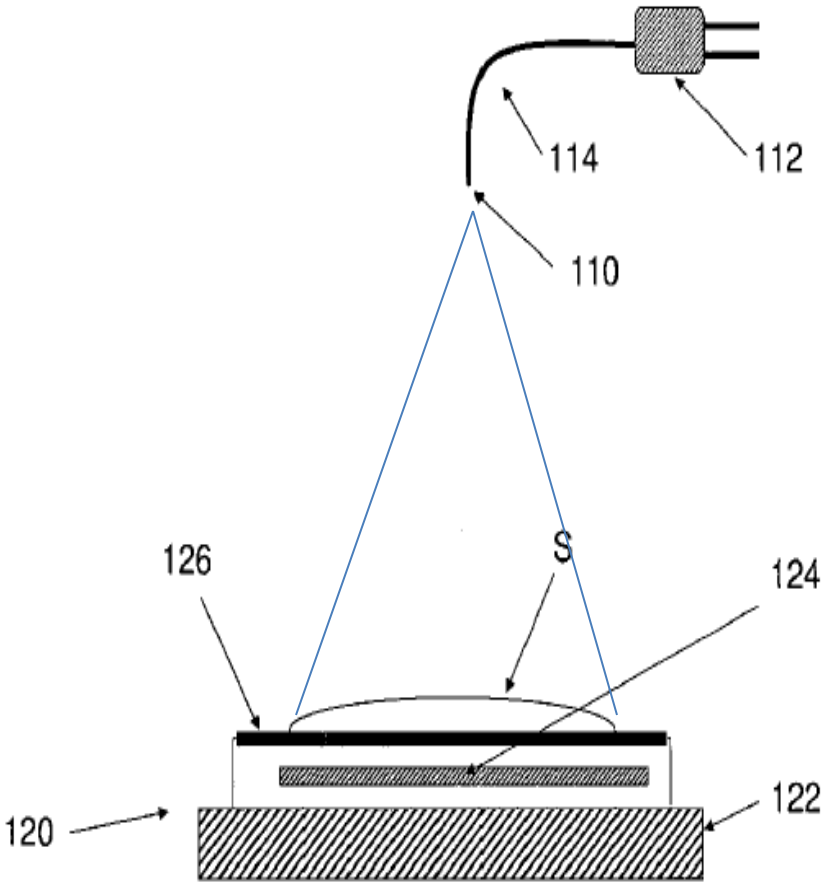



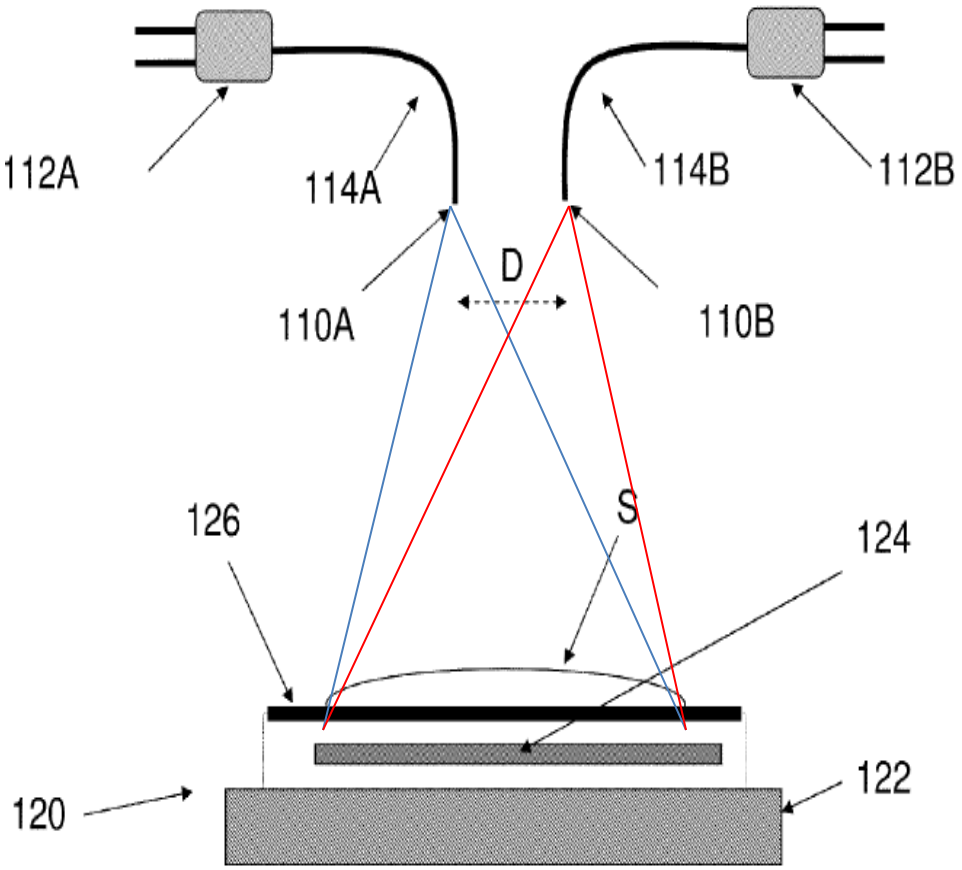
# 3D movement of 22 Rotifer in 5 mm of water, 30 frames in 1 second



# Mono Shadow Microscope




# Stereo Shadow Microscope




**Inventors: Barton A. Smith & Thomas G. Zimmerman, Priority date <u>April 20, 2007</u>**

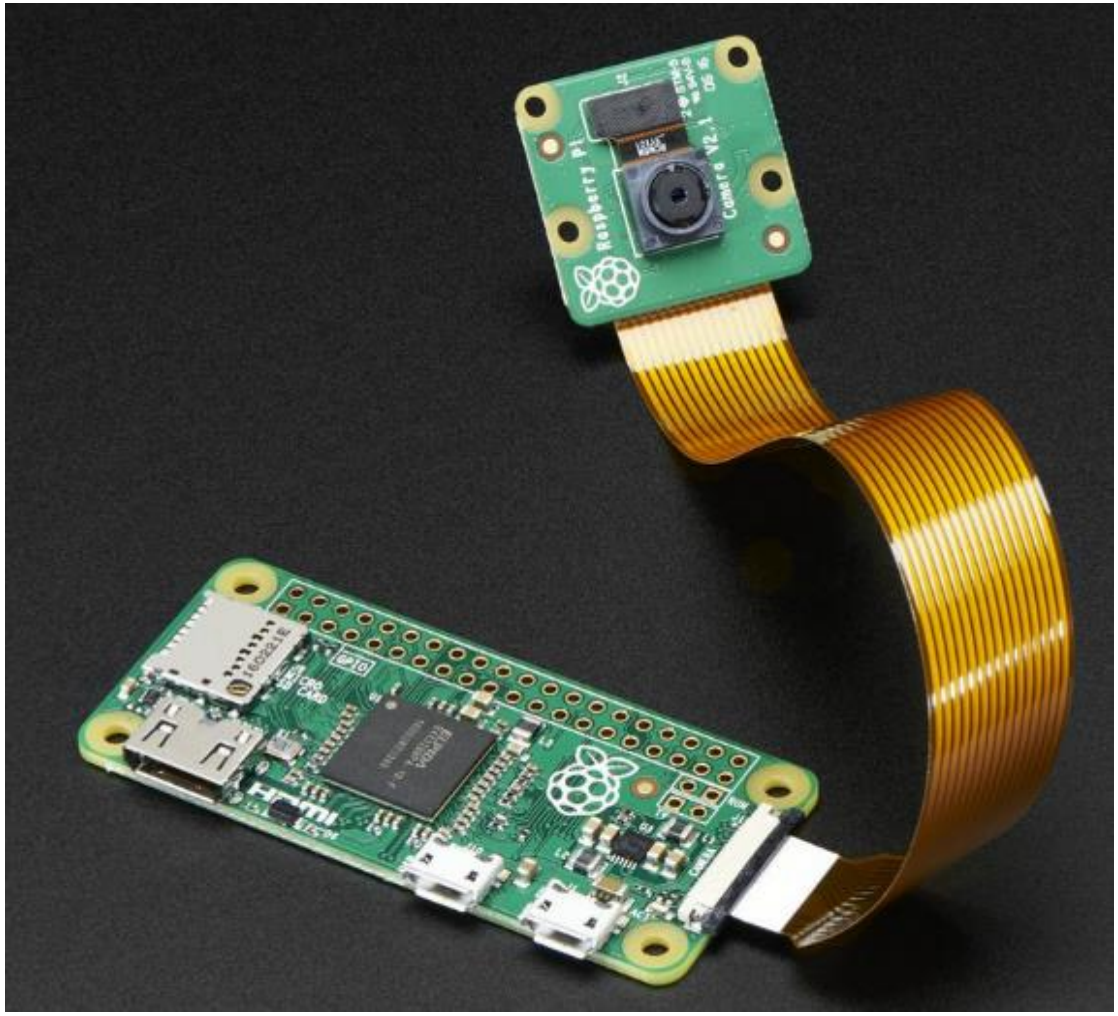
| | | | | | |
|---|---|---|---|---|---|
| **Patent No.:** | **US 7,936,501 B2** | **Patent No.:** | **US 8,027,083 B2** | **Patent No.:** | **US 8,446,667 B2** |
| **Date of Patent:** | ***May 3, 2011** | **Date of Patent:** | ***Sep. 27, 2011** | **Date of Patent:** | **May 21, 2013** |

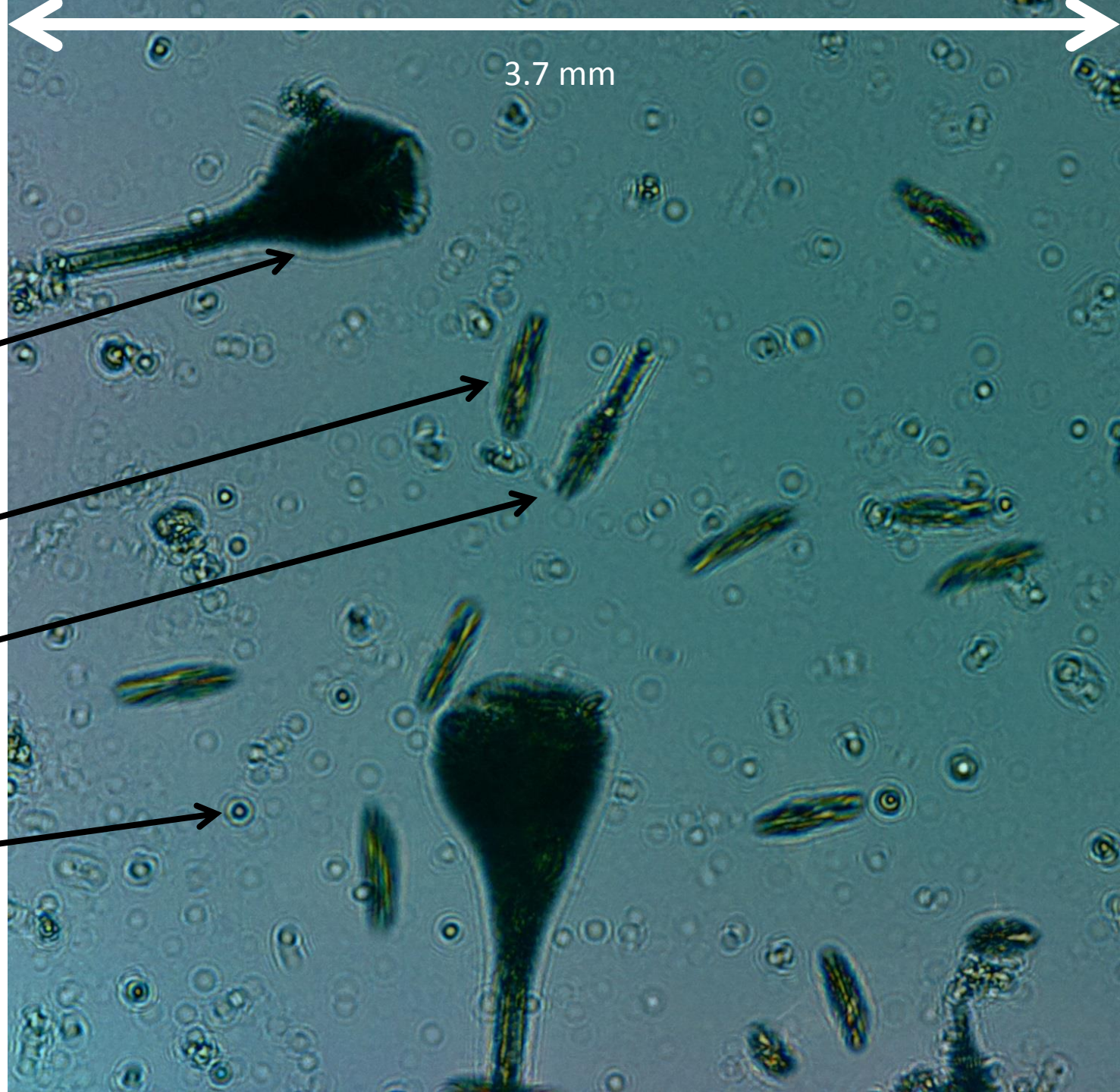
# Digital Stereo Microscope

Raspberry Pi ZeroW $10
(4 core ARM $40)
Image Sensor $8

ARM Processor
Linux OS, Python,
OpenCV
HDMI Output

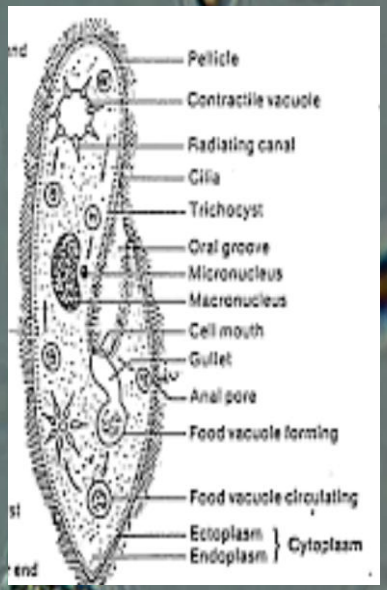
5 Mpix Image Sensor
1080p Video
3.7 mm x 2.7 mm



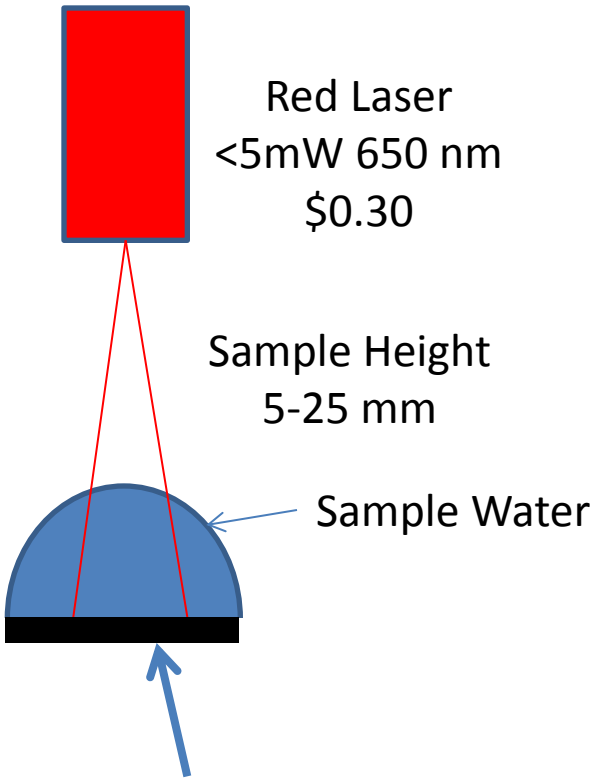

3.7 mm
Stentor
Paramecium
Bdelloid Rotifer
Ciliates

TED Ideas worth spreading

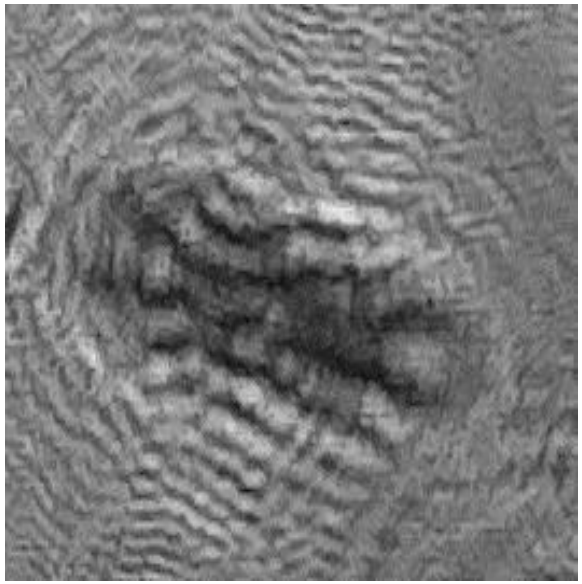
# The wonderful world of life in a drop of water


Pellicle
Contractile vacuole
Radiating canal
Cilia
Trichocyst
Oral groove
Micronucleus
Macronucleus
Cell mouth
Gullet
Anal pore
Food vacuole forming
Food vacuole circulating
Ectoplasm
Endoplasm
Cytoplasm

# In Line Holographic Microscope

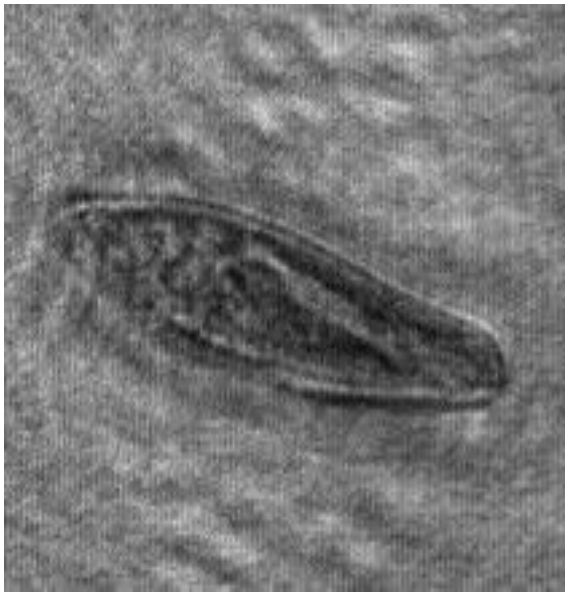



Original Hologram



376 um

Reconstructed Image
Z=1.4 mm



Paramecium

Image Sensor
OmniVision OV5647
Resolution: 2592 × 1944 pixels (5 Mpix)
Image Sensing Area: 3.76 × 2.74 mm
Pixel Size: 1.4 µm × 1.4 µm

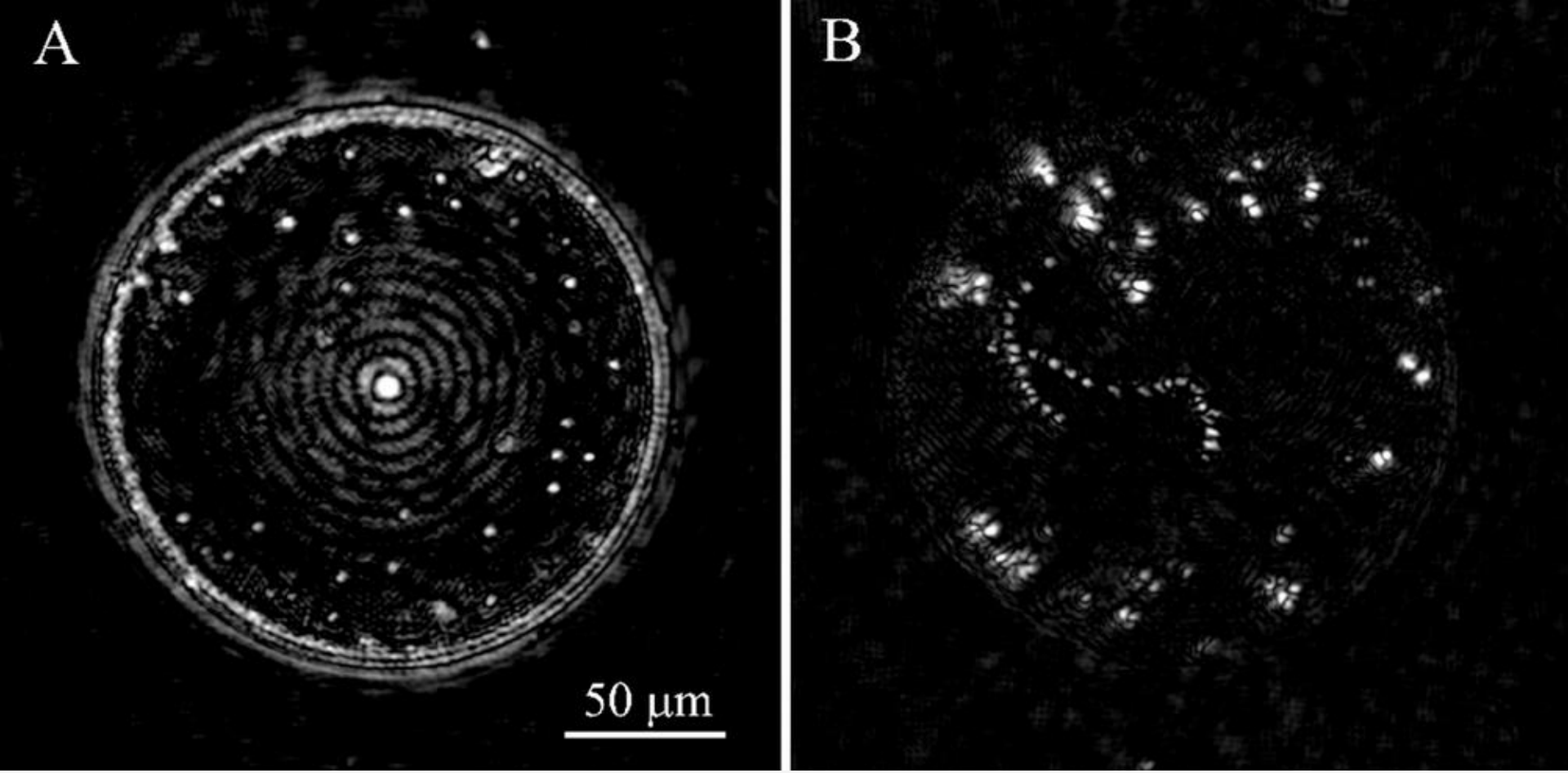
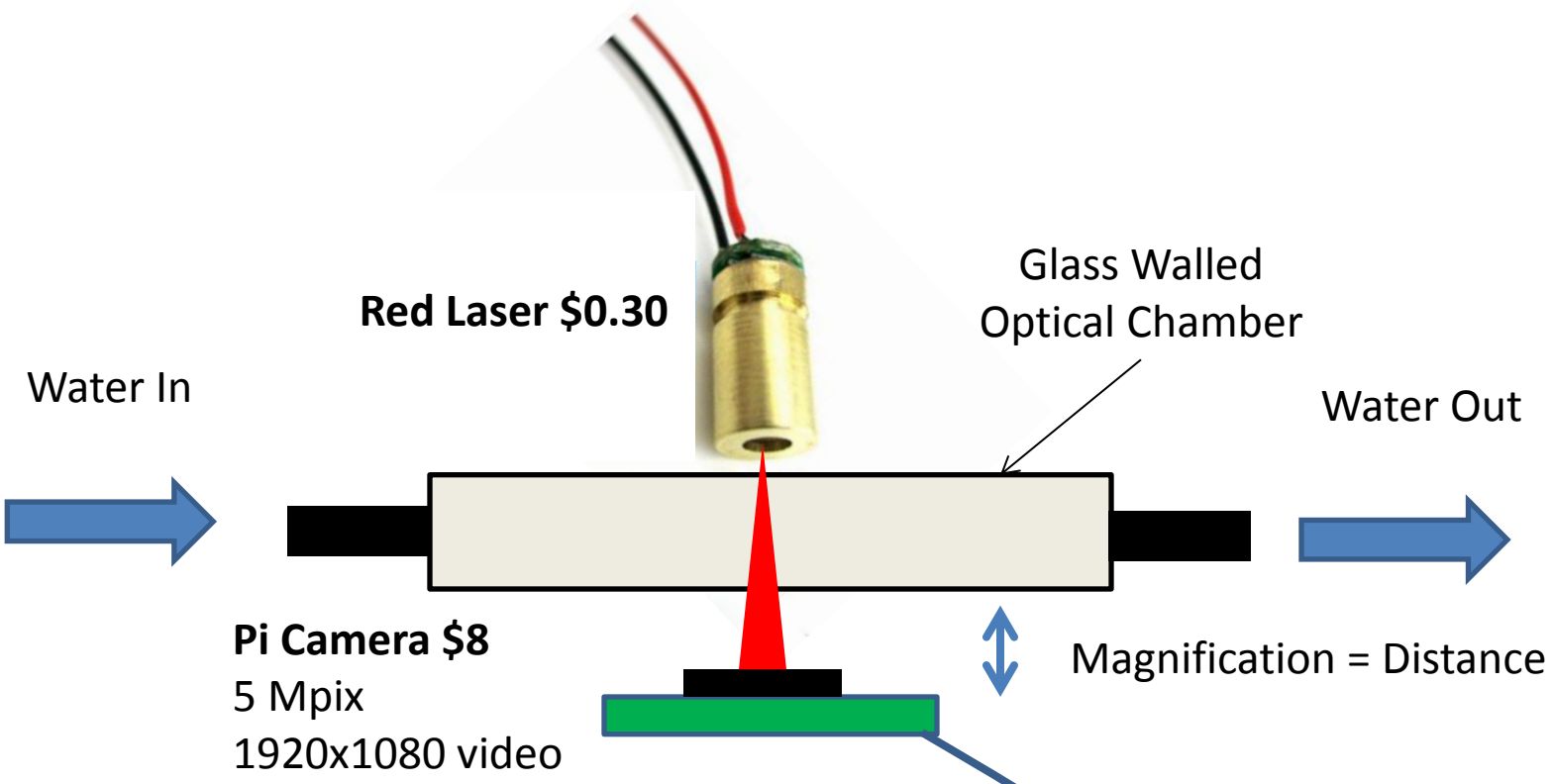


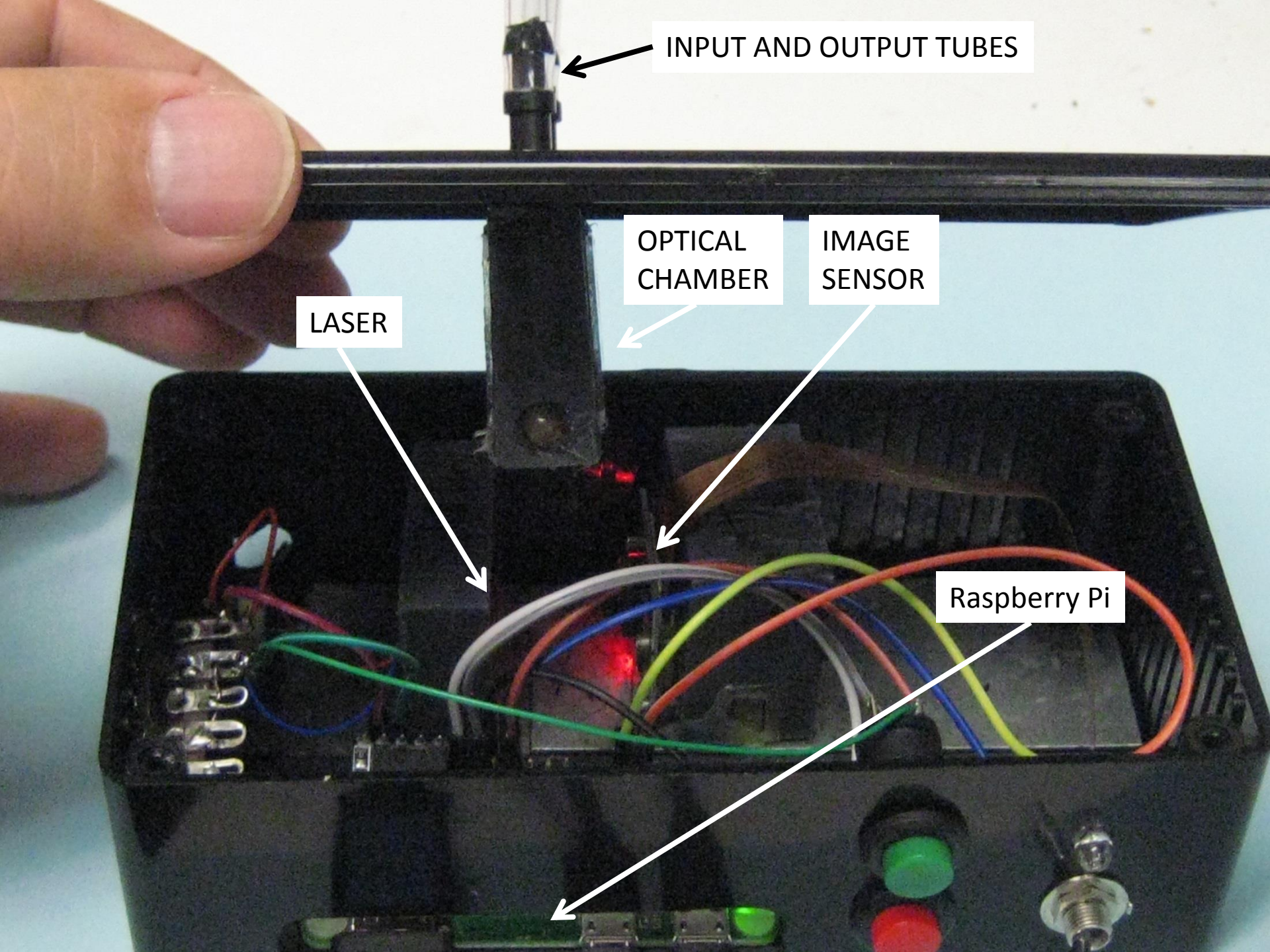

Fig. 12. Bacteria in a diatom (Coscinodiscus wailesii). A, Reconstruction from one hologram showing the siliceous outer shell with labiate processes (bright spots); B, reconstruction of bacterial trajectories from a difference hologram composed of a time series of 20 holograms taken 1.3 s apart. Green laser; 0.5um pinhole; pinhole to sample (diatom), 1 mm; numerical aperture, 0.22.

https://www.semanticscholar.org/paper/Digital-in-line-holographic-microscopy.-Garcia-Sucerquia-Xu

# Direct In-Line Holographic Microscope

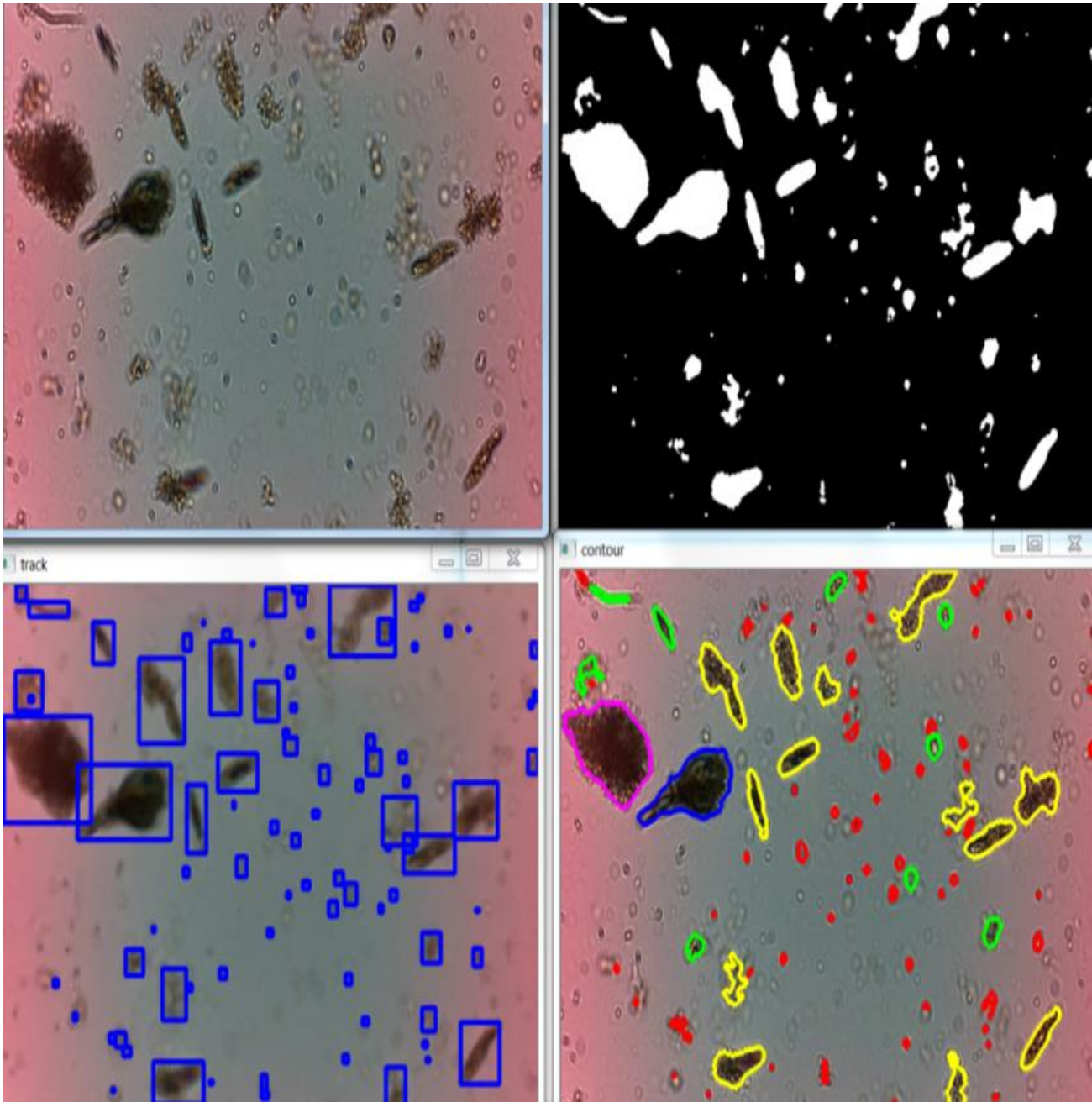



**Pi Zero W $10**
ARM processor
HDMI video output
32 GB SD card
USB port
WiFi, Bluetooth


INPUT AND OUTPUT TUBES
OPTICAL CHAMBER
IMAGE SENSOR
LASER
Raspberry Pi

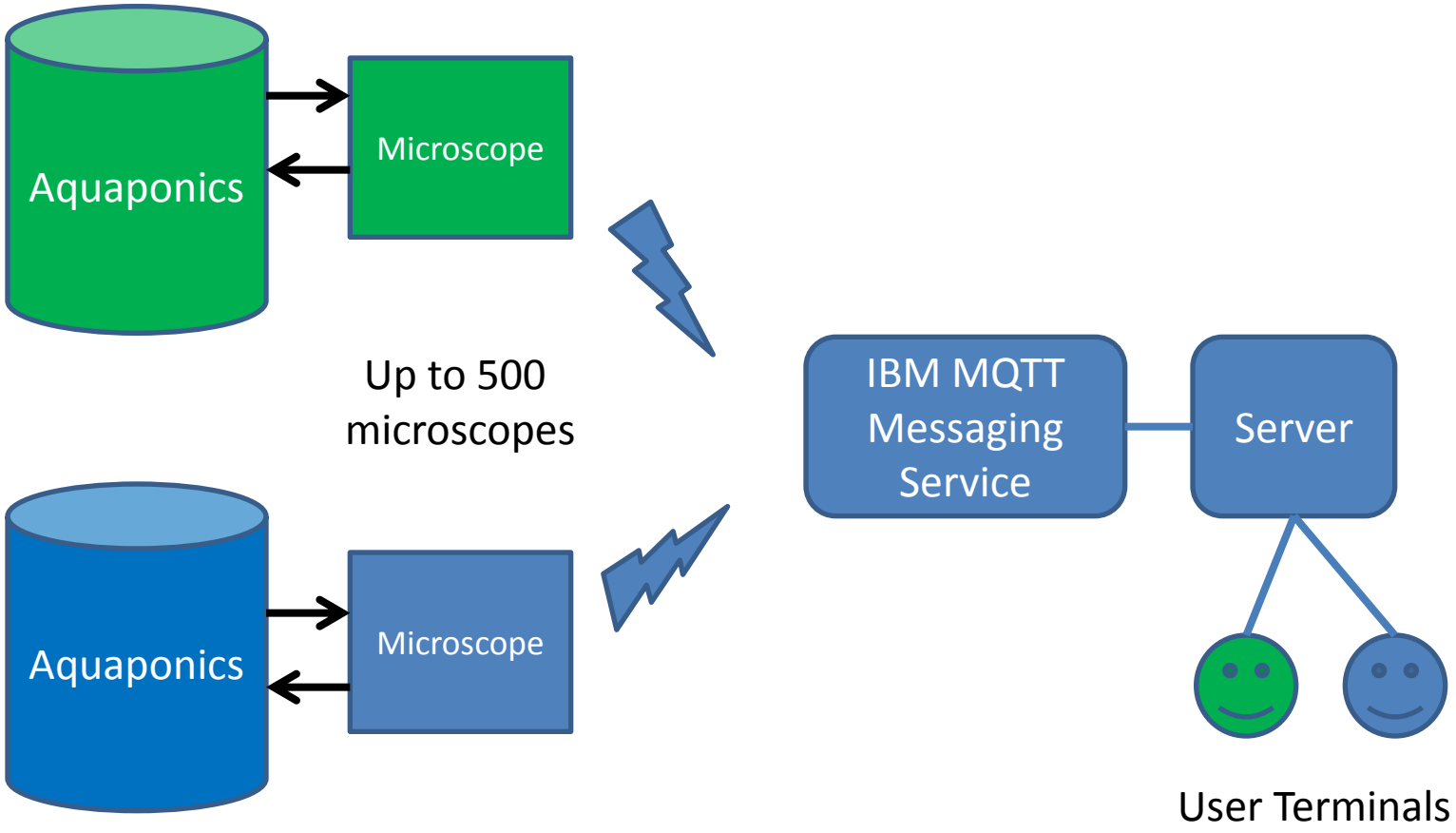
# Image Processing to Track and Classify Plankton

- Disturbance
- Healthy
- Behaviour
- Species
- Features
- ID
- Track
- Detect



# MQTT Networked IoT Microscope

Saves histogram of plankton size distribution and representative images from each histogram bin.



# Links To Videos

Home Page: researcher.ibm.com/researcher/view.php?person=us-tzim
Build a lenless microscope from a web camera www.youtube.com/watch?v=xm750WtlFN0
TED Talk: https://www.youtube.com/watch?v=VxE_itIllxE
5in5 Talk: https://www.youtube.com/watch?v=Vg92XGT0VhQ
Plankton Movie: https://www.youtube.com/watch?v=ynyjBlVWYWg
Cellular Engineering Lab: https://www.facebook.com/IBM/videos/1686577738099168/