

Portable Magnetic Resonance Technology for Label-free, Rapid Disease Diagnosis

Singapore- MIT Alliance for Research and Technology
Massachusetts Institute of Technology



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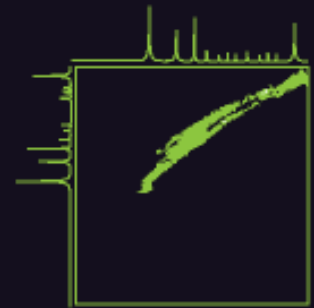
In collaboration with:

Nanyang Technological University
Singapore Immunology Network

Magnetic Resonance Technology

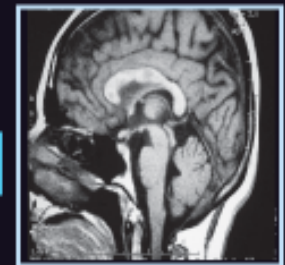
"When a specific NMR-active nuclei spin is placed under a strong external MAGNETIC field, these spins will precess at its Larmor frequency, ω_0 . A short ac-pulse, ω_0 can be applied to tilt these spins at RESONANCE to an orthogonal angle, these spins will eventually return back to its thermal equilibrium and along the way emit (free) induction decay (FID). A very unique chemical signature for each and every nuclei spins."

APPLICATION



spectroscopy

no magnetic gradient



imaging

3-axis magnetic gradient

no magnetic gradient

+

microfluidic technology?

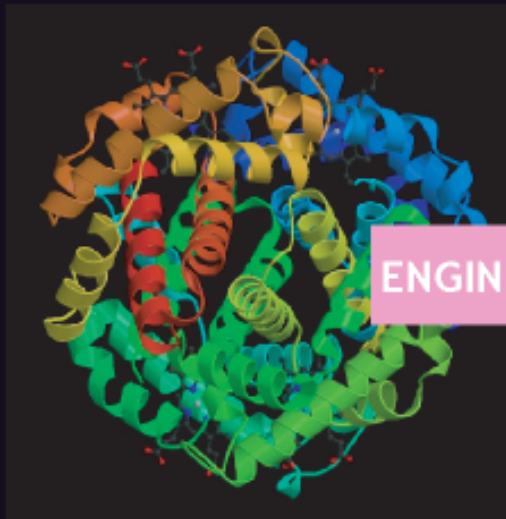


diagnostic relaxometry

ENGINEERING TOOL



HUMAN



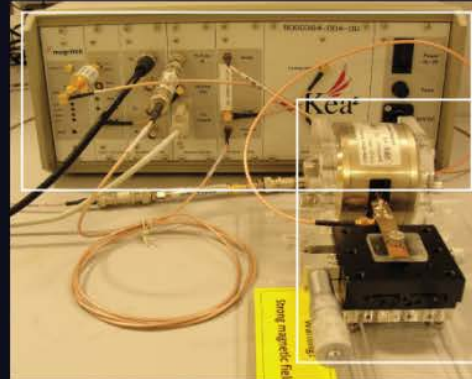
NATURE

Technologies in SMART, MIT

SMART

2009-2011

Singapore-MIT Alliance for Research and Technology



1 kg-
magnet

... 2011 (conventionally)



size : one big room
weight : a few tonnes
cost price : ~ \$ millions

Nuclear Magnetic Resonance Spectroscopy
Magnetic Resonance Imaging

Bench-top

size : 50cm x 30cm x 15cm
weight : ~ 2.5 kg
cost price : ~ \$ 50 000

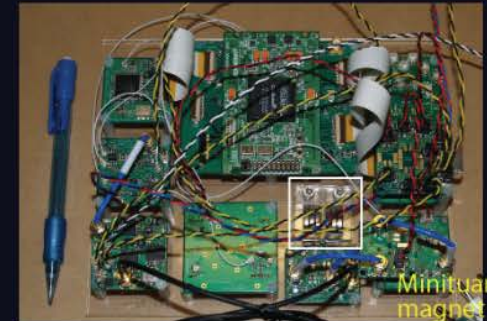
Applications :
Hospital, Clinics

SMART

2011 ...

Singapore-MIT Alliance for Research and Technology

in collaboration with Dr. Takeda, Kyoto University



Miniaturized
magnet

Point-of-care (under progress)

size : 20cm x 18cm x 2cm
weight : 500 gram
cost price : ~ \$ 2500

Applications :
*Portable device
Personal use
Resource-limited areas*

Life-cycle of *plasmodium* spp

Infected rbc : highly paramagnetic (hemozoin, Fe^{3+})

Uninfected rbc : diamagnetic (oxyhemoglobin, Fe^{2+})

Relaxation rate enhancement, $\Delta R_2 \sim$ magnetic susceptibilities

metabolite pathway

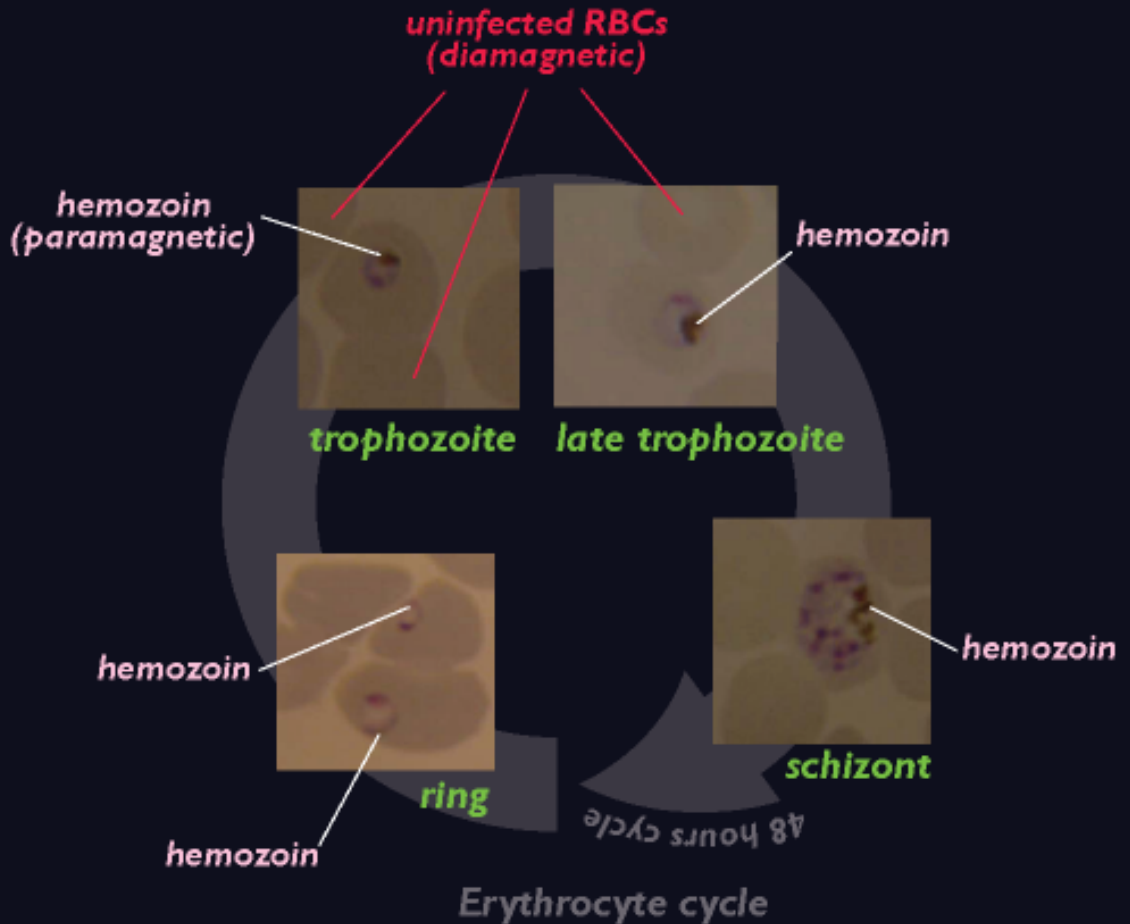
hemoglobin, $Fe(II)$

digest

free heme, (radical)

detoxified

hemozoin, $Fe(III)$



Addressing the NEEDS?

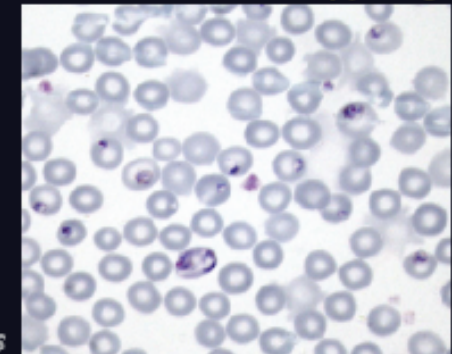


Microscopy technique

current "gold standard"
sensitivity (50-200 parasites/uL, 30-50min)
cost per slide (\$0.50)
manual operation
skillful and trained workers
tedious sample preparation



Microscopy image



1 uL = 5 million RBCs

Commercialized kits (QBC, dipstick)



Speed (~ 10-15 min)
cost (\$0.60-\$3.00)
No quantitative info (crude estimation)

Non - Microscopy technique (PCR)



highly sensitivity (5 parasites/uL, 3-4 hours)
detailed info on parasite's strains
cost per assay (\$3)
highly skillful workers and technology
no info parasitemia level

Setup for MRR

W.K. Peng, J.Han,

"A Biosensor And Method Based On Magnetic Resonance

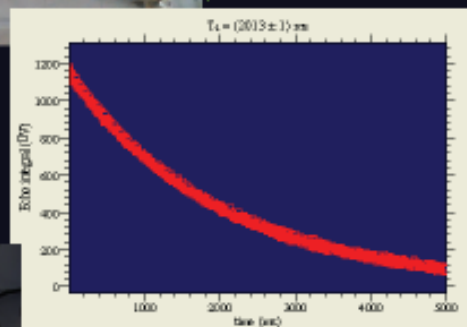
Relaxometry" US Provisional Patent Application No. 61/447,339; ILO Ref: 103475-BS-US/PRV

0.5T Permanent Magnet



hematocrit
tube (infected
blood)

rf-probe



R2-relaxation signal

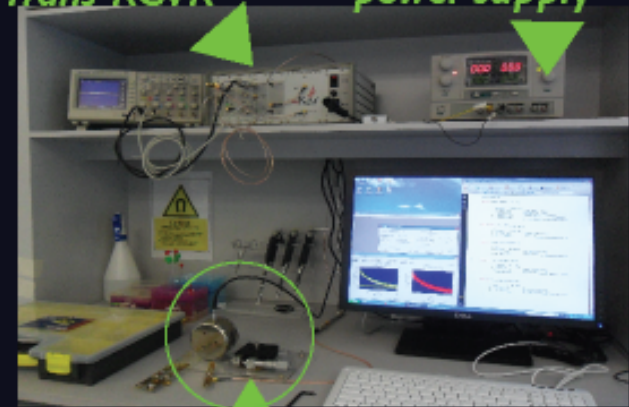


micro-centrifuge

Integrated sample prep & detection

Rf Trans-RCVR

power supply



Relaxometry sensor

Sensitivity

scan time

: 24 seconds

sample volume

: 320 nL

Specificity

Parasitemia Level

limit of detection : 10 parasites / μ L

Stages of infection: Yes

Salient features

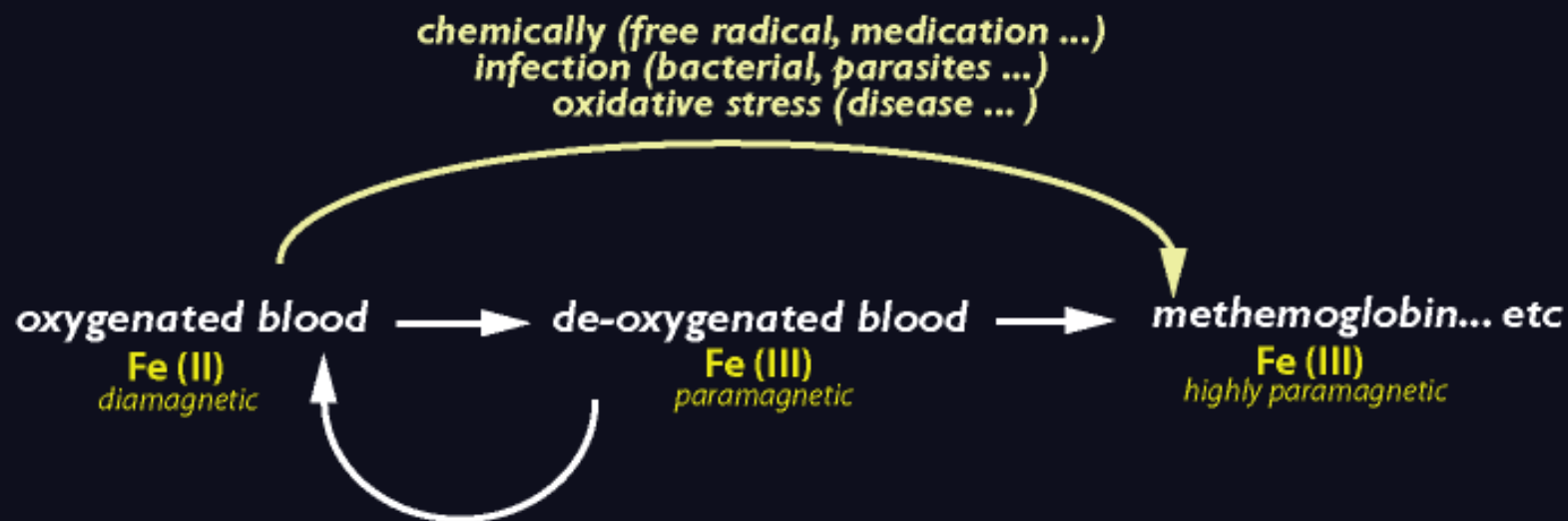
Label-free (magnetic, fluorescent beads etc)

Minimal Sample Processing (<5 minutes)

Parallel Sample Processing

(hundreds of samples)

Generic Platform for Oxidation/Oxygenation Blood Detection ?



Oxidative stress ?



heart disease, stroke, cancer, diabetes, ...