Light activated bionanodevices

Presented at CSIR B60 Conference - Pretoria

Unit: National Laser Centre

Dr. Raymond Sparrow

Senior Researcher in Biophotonics

27th February 2006

our future through science

Agenda

- Nano – overview
  - Why nano?
- Nanotechnology
  - Overview
  - Advantages
  - Problems
- Bionanotechnology
  - Why bio-nano?
- Bionanodevice project at NLC
  - Outline of project
- Energy transfer using LHC
  - Principles for energy supply and transfer
- Energy conversion
  - Outline of component
- Kinesin motor protein
  - Principles for movement

Nano - overview

- There is a constant drive to reduce the size of components and machines.
- The properties of materials at the nanoscale are very different to the properties in there bulk phase.
- Technology using components on the nanometer scale.
- Utilising and manipulating individual atoms or molecules.
- Bio-nanotechnology uses biological materials or systems.

Nanotechnology

ADVANTAGES

- New materials
- New properties
- Greater efficiency
- Reduced size (compactness)

PROBLEMS

- The assembly of components.
- Interconnecting components into working mechanisms
- The control of components

Bionano - overview

- Many problems of nanoscale mechanisms have been overcome in nature.
- Act at the nanoscale
- More energy efficient.
- Hence a great interest in investigating biological materials and systems.
  - Actin, Myosin, Kinesin (movement)
  - ATPsynthase, Photosynthetic pigments (Energy transduction)
  - Many biological systems are self assembling (Protein/DNA/Membranes)

A Light activated bio-nanodevice

- Creating a device that will move a tubule/rod in 8nm controllable steps.
- The device has three sections (modular).
- It uses the principles of:-

  - PHOTOSYNTHESIS
  - ATPsynthase ATP PRODUCTION
  - KINESIN MOTOR PROTEIN MOVEMENT

A Light activated bio-nanodevice

- SECTION A – ENERGY TRAPPING (LIGHT HARVESTING) AND TRANSPORT.
- SECTION B – ENERGY CONVERSION.
- SECTION C – MOVEMENT (CAN BE AN ALTERNATIVE COMPONENT).

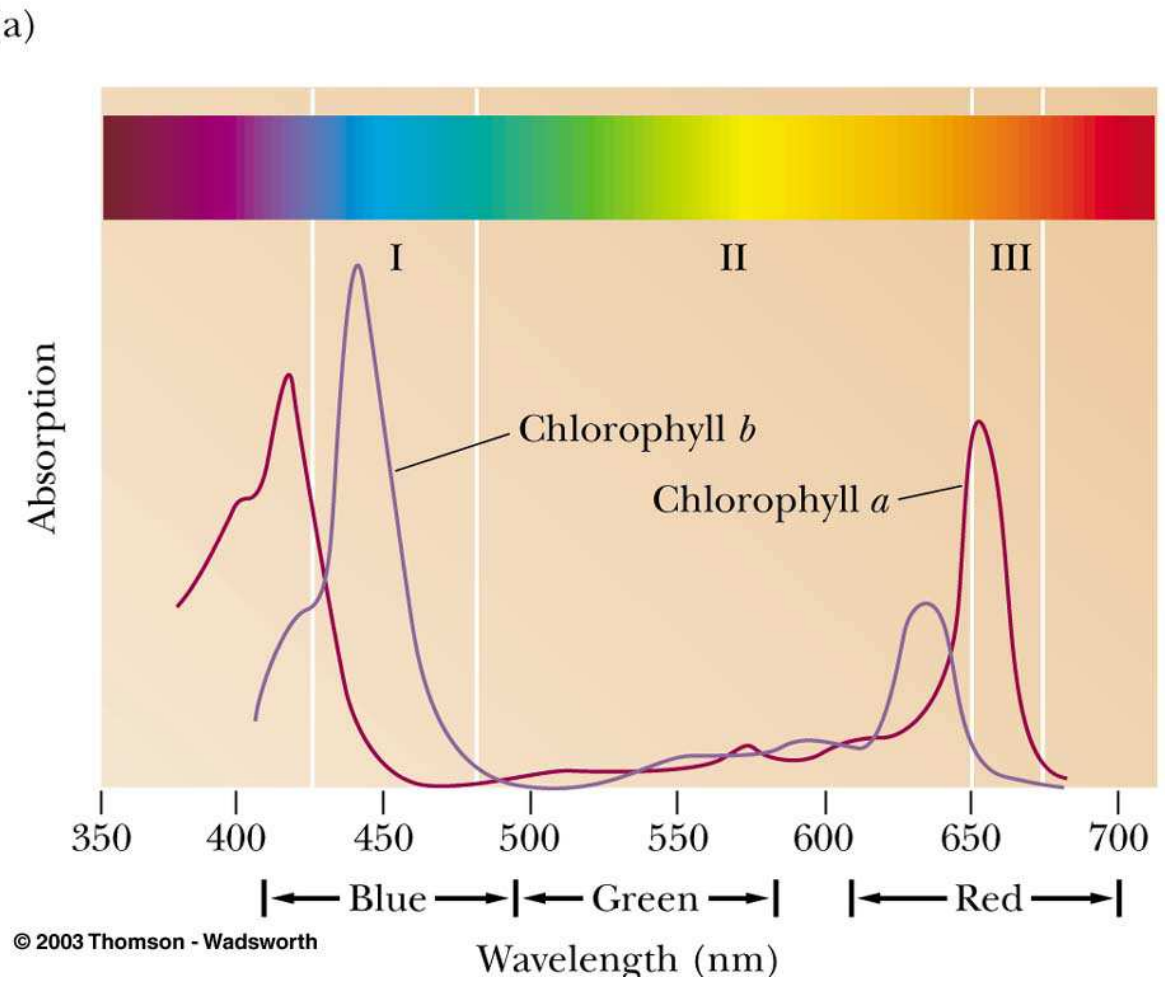
Section A

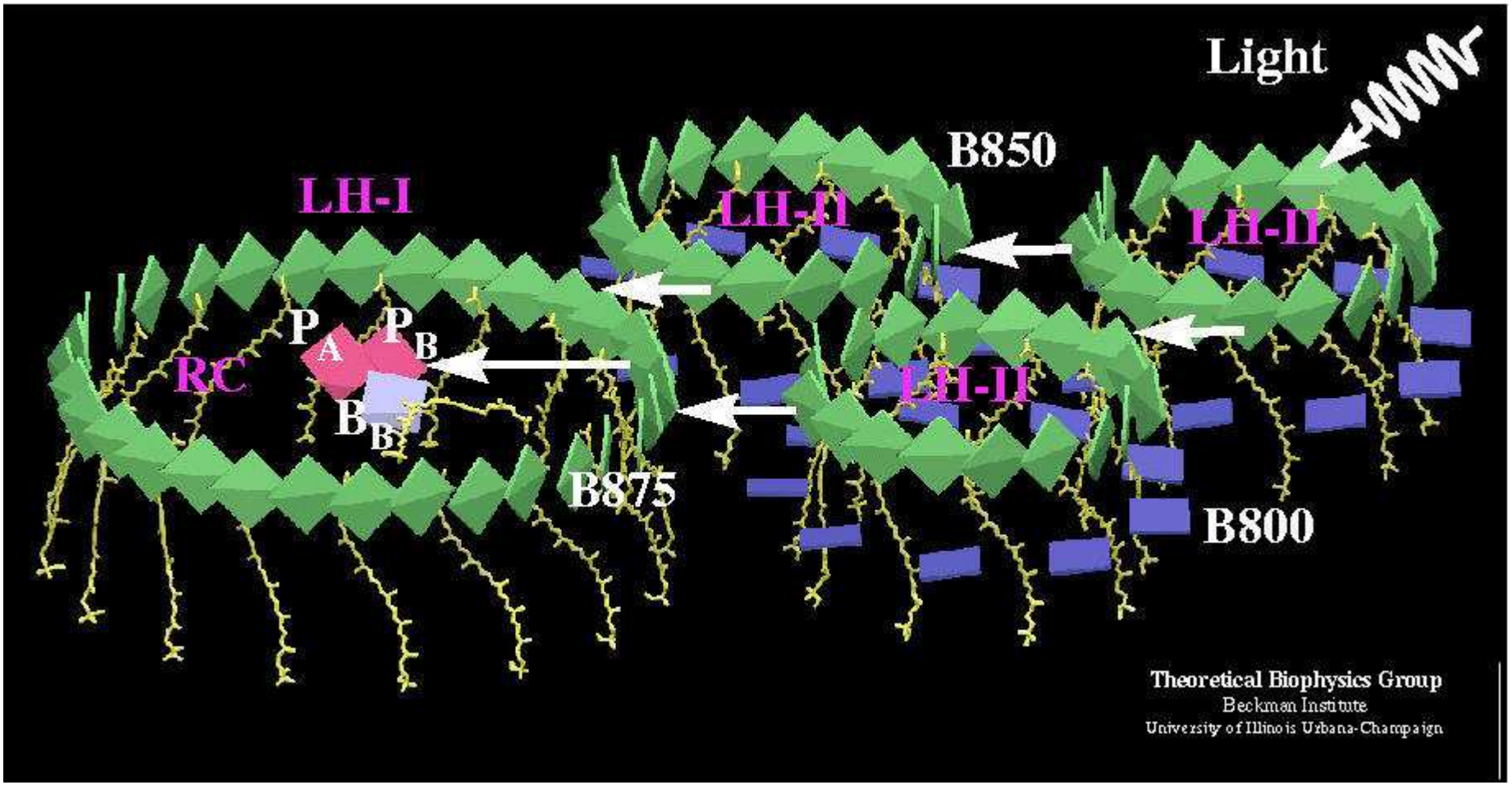
ENERGY TRAPPING (LIGHT HARVESTING) AND TRANSPORT.

Chlorophylls (Chl) a & b

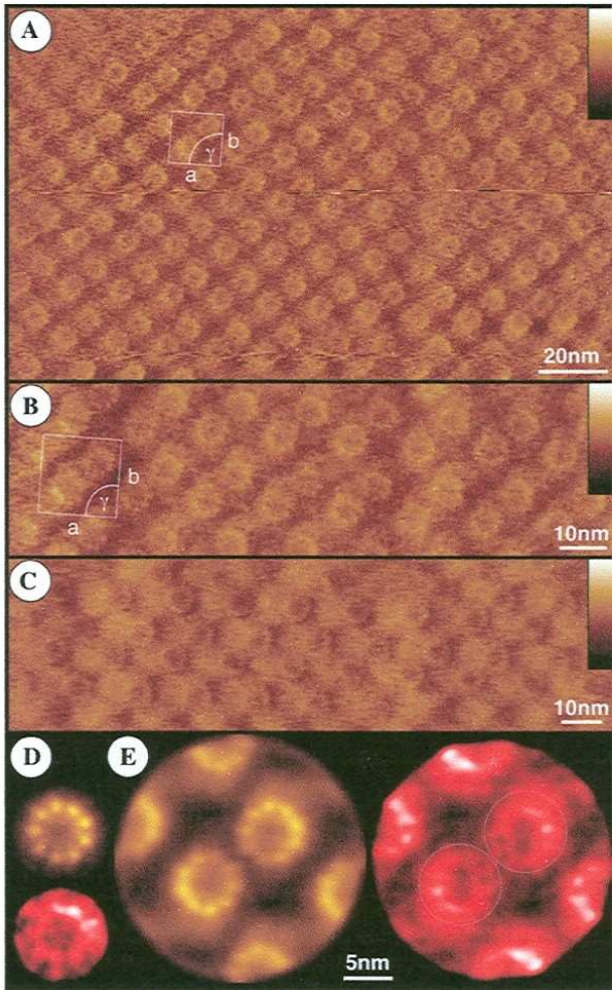
- Absorb red (600 - 700 nm) and blue (400 - 500 nm) light
- Antennae chlorophylls gather light
- Harvested light energy passed to specialized Chl molecules, a reaction center
- Chlorophylls arranged in photosynthetic units
- Generally several hundred light-harvesting antennae Chl for each Chl at a reaction center
- Chemical reactions of photosynthesis begin at reaction centers

ABSORPTION OF LIGHT BY CHLOROPHYLLS *a* and *b*



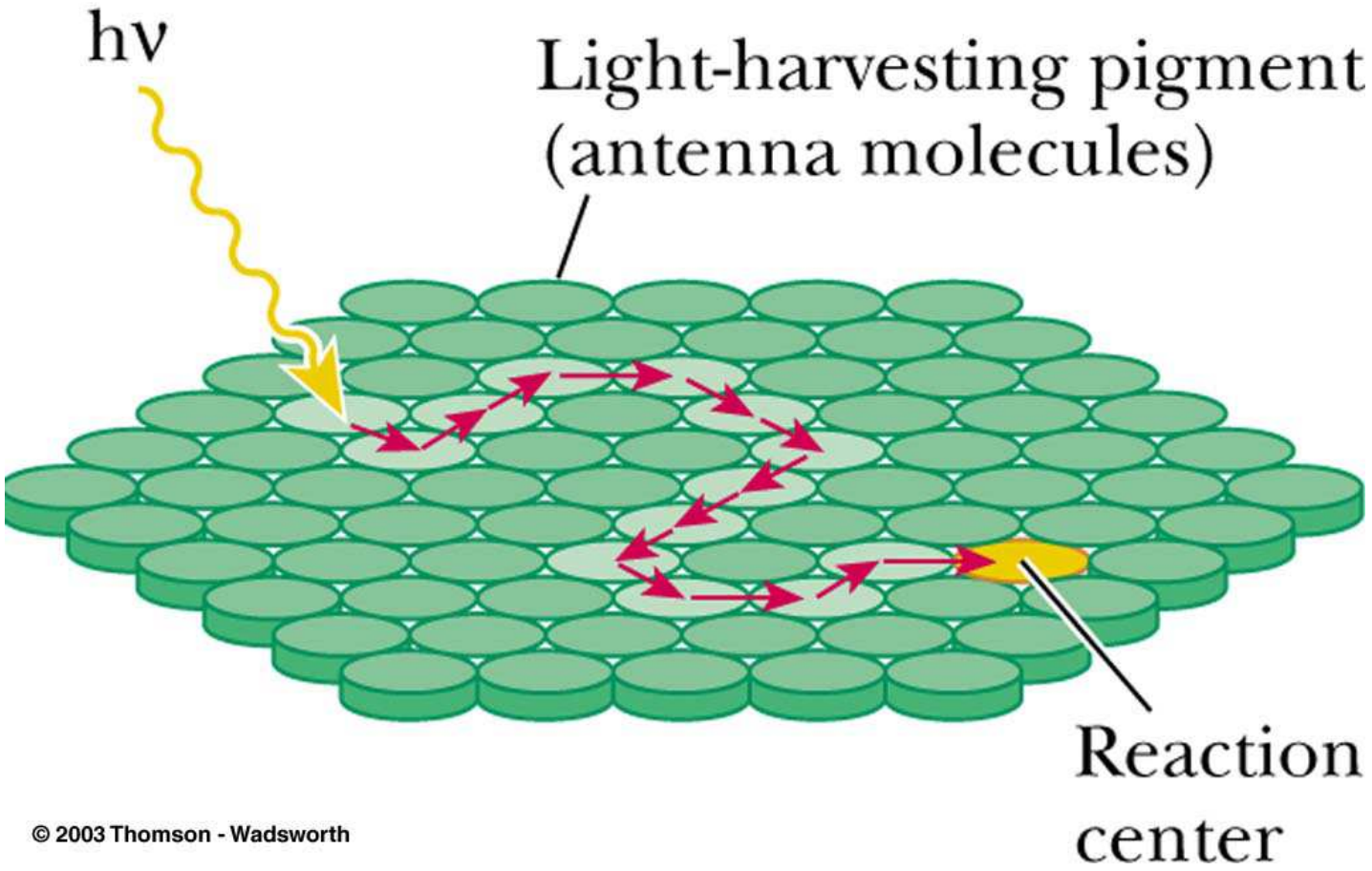


AFM OF LHC



GONÇALVES, BUSSELEZ, LÉVY, SEGUIN AND SCHEURING J,STRUCTURAL BIOL. 149 (2005)

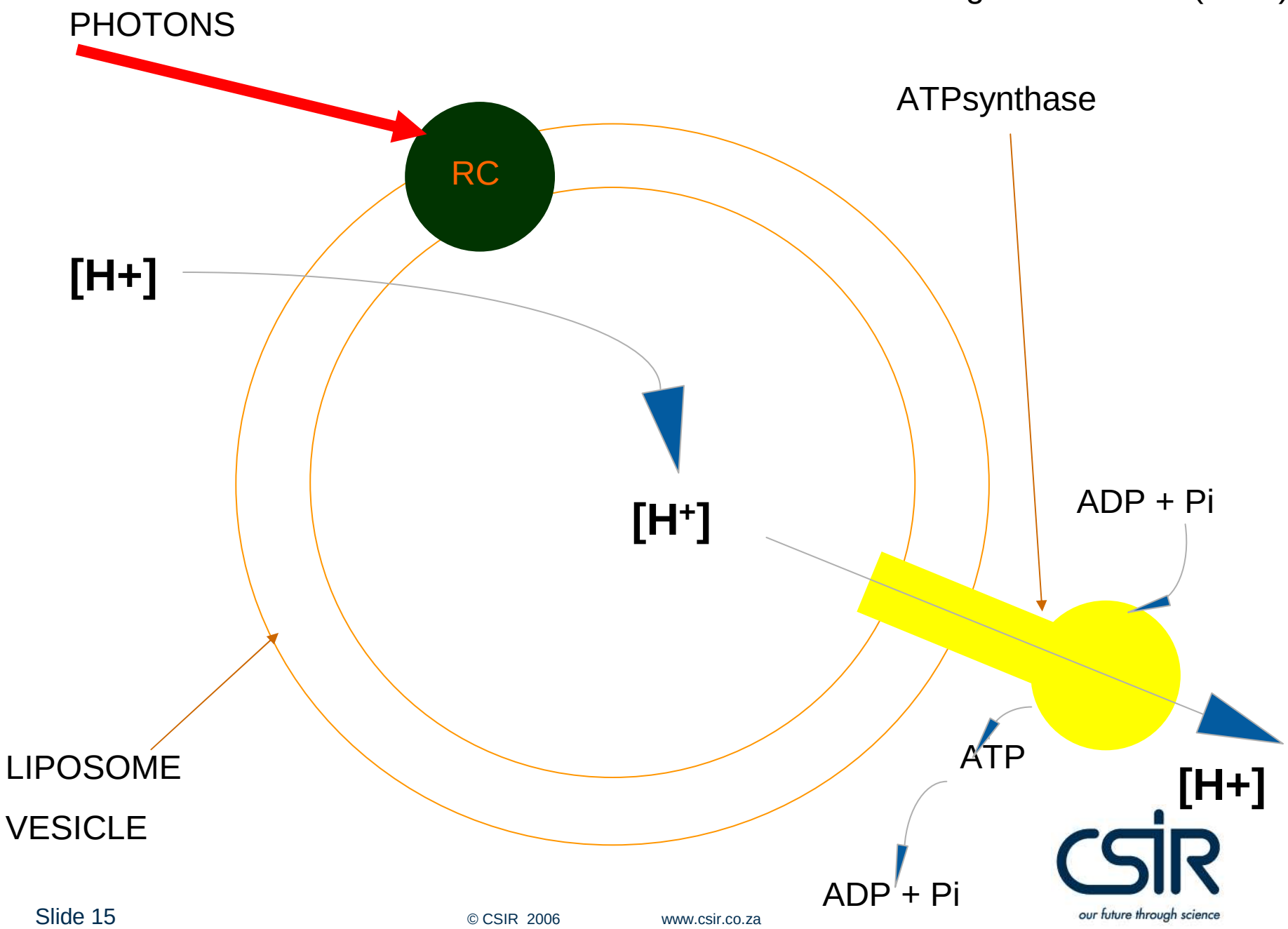
A PHOTOSYNTHETIC UNIT



Section B

ENERGY CONVERSION.

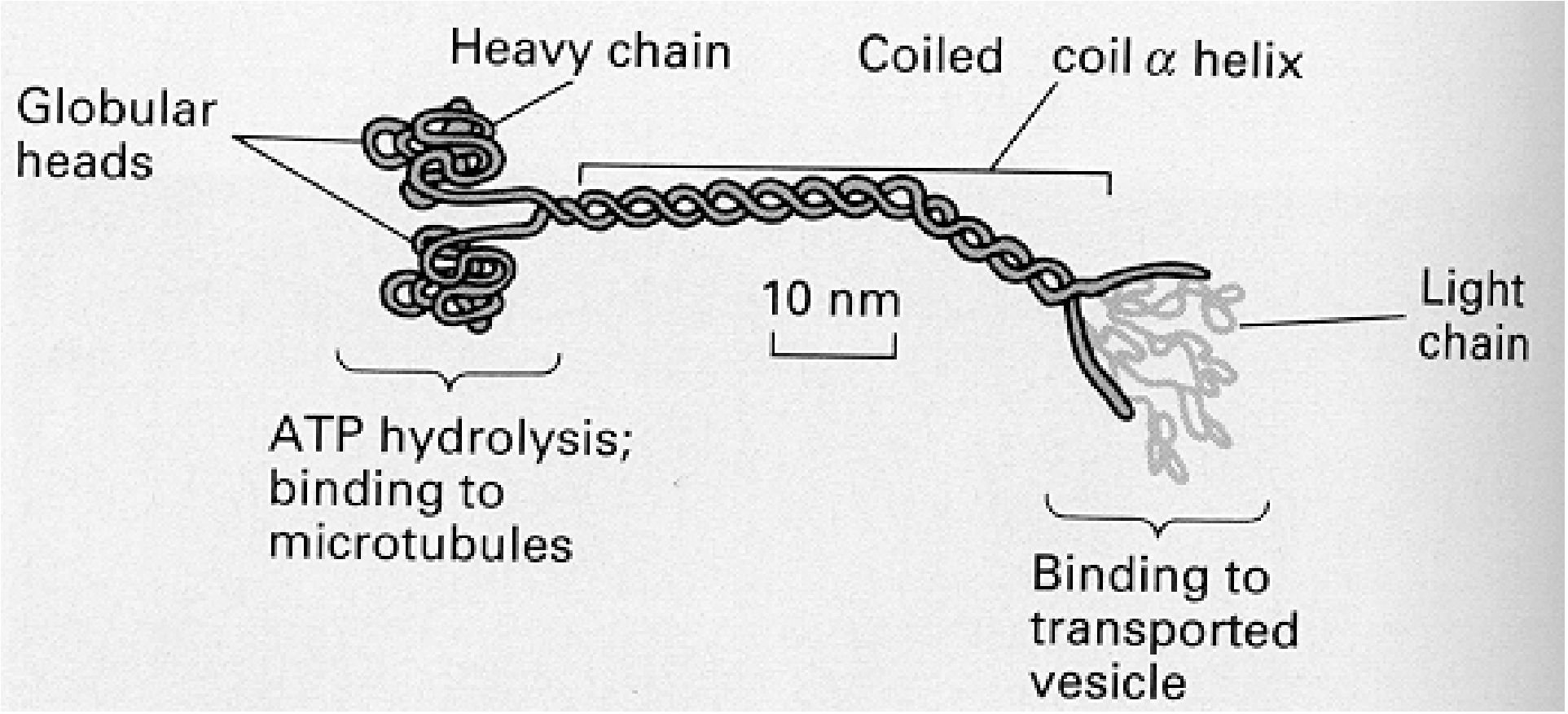
Steinberg-Yfrasch et.al (1998)



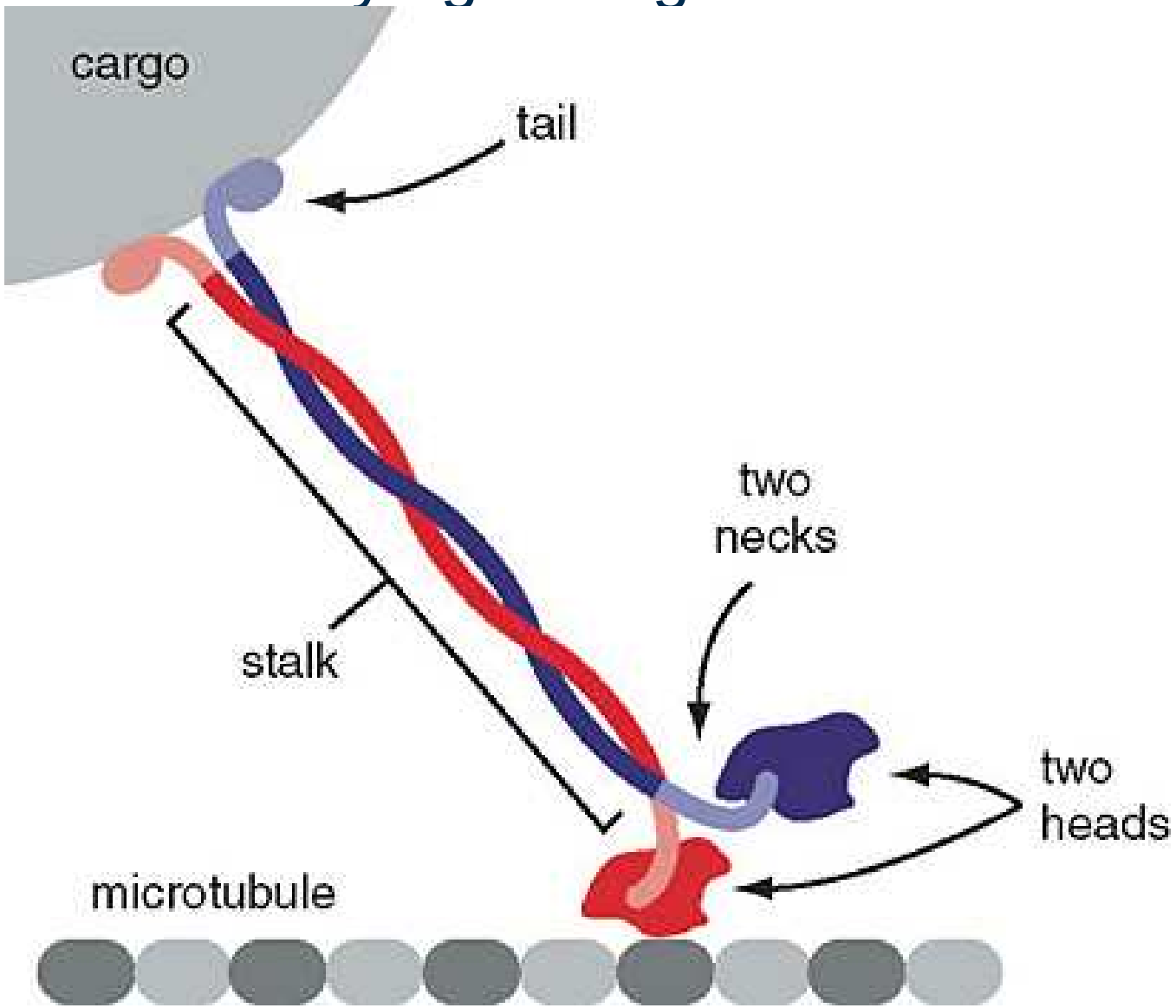
Section C

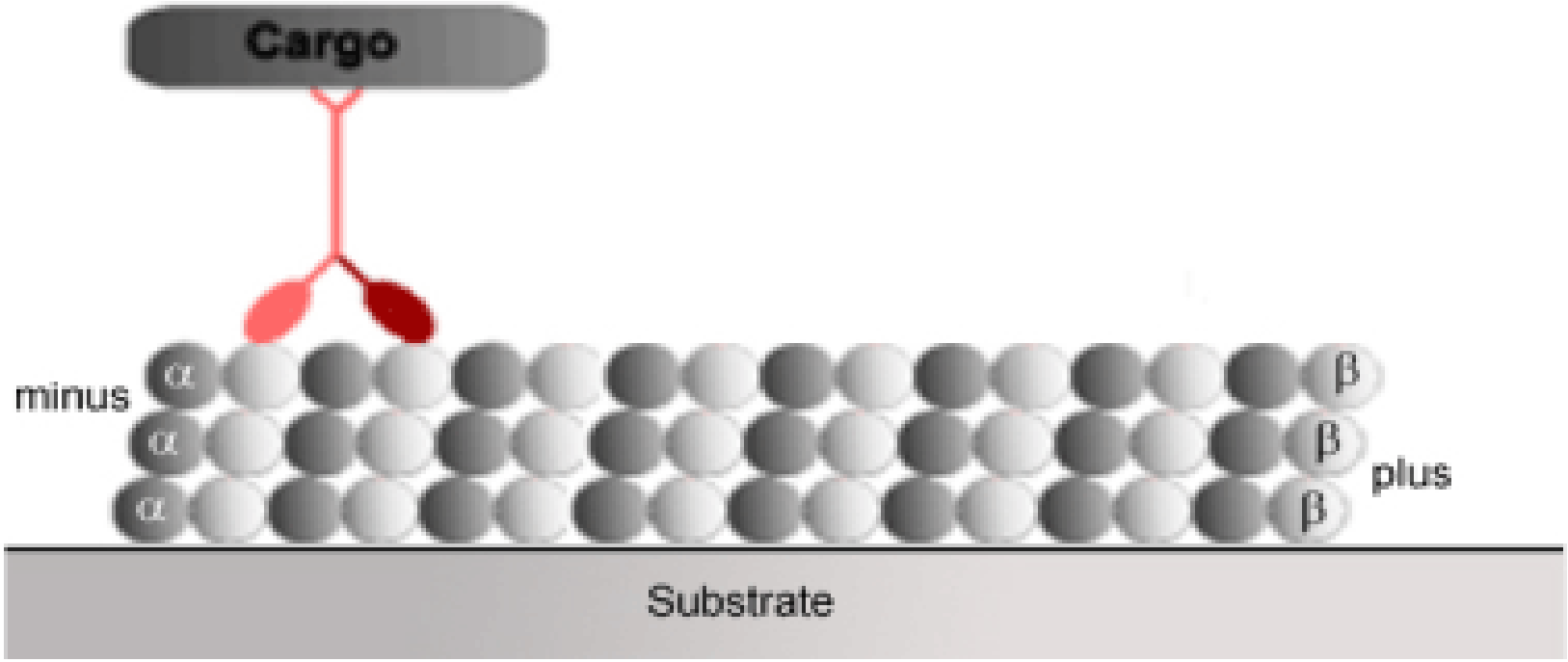
MOVEMENT

The structure of Kinesin



Kinesin carrying a cargo





Current and future work

Collaborations

Professor Barzda, University of Toronto.

- To determine LH II organisation for potential energy transfer domain size.
- Utilising non-linear microscopy to detect fluorescence, second and third harmonic data.
- To corroborate this technique with CD spectroscopy data and develop a micro-CD spectroscope.

Dr.Grobler – NWU (Potchefstroom)

- vesicle production.

Laser experimental requirements

- Femtosecond Pulsed Laser System
- Excitation Wavelength Regions 400 – 900nm (1.5x1015 Photons cm-2).
- Probe Wavelength Regions 400 – 900nm (1013 Photons cm-2).
- To Measure Ultra-fast Transient Absorption and Fluorescence Data.
- To Measure Intensity Dependent Data.

Finally

You are very welcome to visit our brand new Biophotonics Group website!

(www.csir.co.za/biophotonics)