Quantum Phenomena and Biology

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FACT OR FICTION?

“Quantum biology is a speculative and interdisciplinary field that seeks to link quantum physics and the life sciences”

http://www.energetic-medicine.net/quantum-biology.html
FACT OR FICTION?

“Quantum biology is a speculative and interdisciplinary field that seeks to link quantum physics and the life sciences”
Quantum in Biology:

Physics of biomolecules and the relevance of these properties for \textit{biological function}

\textit{biochemistry and molecular biology} meets \textit{quantitative laws of quantum physics}
Biological processes of interest

Figure taken from Lambert et al Nature Physics, 9 10-18 (2013)
Relating quantum phenomena to **biomolecular** function

**nano-scale system**

LH antennae

Odor receptor

cryptochrome

**nano-scale process**

Energy transport

Molecular sensing

Magnetic sensing

**Quantum phenomena**

Superposition of collective electronic states?

Inelastic electron tunnelling?

Quantum correlated radical-pairs?
FACT OR FICTION?

“Beard-Einstein conflation is a fundamental theory underlying high-efficient energy transfer in photosynthesis”

Solar: Ian McEwan
Open quantum system description

“Observable” system

- photo-induced process
- electronic degrees of freedom
- environment

“Measurement”
Example: light-harvesting antenna

System: collective electronic excitations

Environment: pigment vibrations, protein vibrations, low-energy solvent modes, etc. Generally described as (quantum or classical) “springs”.

Measurement: linear and non-linear spectroscopy
Example: Two-pigments

Collective electronic excitation states

\[ X \left( E_X \right) \quad Y \left( E_Y \right) \]
### Quantum regime

<table>
<thead>
<tr>
<th>PXX</th>
<th>PXY</th>
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<tbody>
<tr>
<td>PYX</td>
<td>PYY</td>
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*off-diagonal = coherencias*

### Classical regime

<table>
<thead>
<tr>
<th>PXX</th>
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<tr>
<td>0</td>
<td>PYY</td>
</tr>
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</table>

*diagonal = probabilities*
Acclimation of quantum properties

B800 nm
B850 nm
B820 nm

Low-light
High-light

Wavelength [nm]
Gene expression controls some quantum properties
Photon echo spectroscopy

Courtesy of Gregory D Scholes
Evidence of quantum superpositions during dynamics
Example: Symmetry-tuning of transfer efficiencies

F. Fassioli, A. Nazir and A. Olaya-Castr, JPCL 1, 2139 (2010)
Relating quantum phenomena to **biomolecular** function

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**Scientific challenge:**
*Does this matter for biology*

Quantum phenomena and Biology

Alexandra Olaya-Castro
Gracias por su atención!!