

Nathan Taylor

Northside Hospital Award

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Second Year ARCS Scholar

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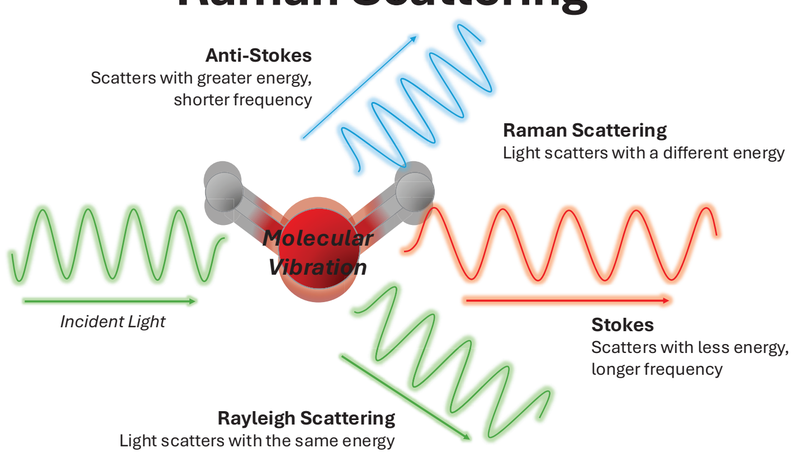
Reading Cellular Chemistry: Biomedical Imaging with BCARS

Broadband Coherent anti-Stokes Raman Scattering (BCARS) microscopy non-destructively maps the composition and spatial distribution of molecules in cells and tissues without labels or stains, opening applications in cancer diagnostics, cell therapy quality control, and developmental biology.

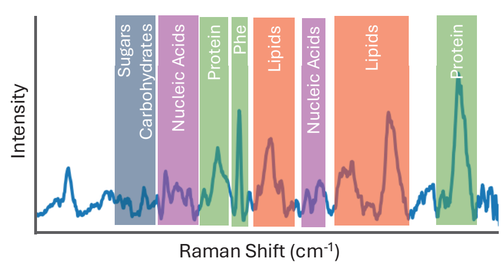
Raman Scattering



Peaks are Molecules

Every chemical bond vibrates at a specific frequency → Raman Shift (cm^{-1})

Biological Raman spectra have thousands of chemical bonds



Raman Spectroscopy:
- Label-free
- Non-destructive

BCARS images have 250,000 biological Raman spectra

Peak position indicates *which* chemical bond
Peak amplitude indicates how much of it

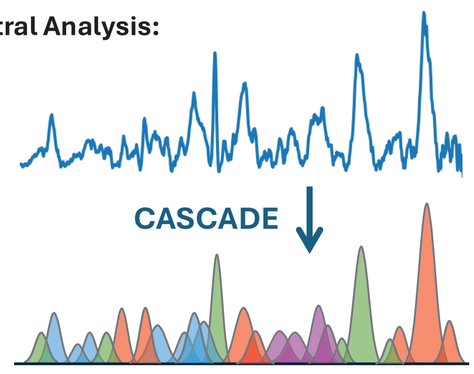
Peak Fitting Tool

Peak-based analysis is like identifying a specific note in a musical chord

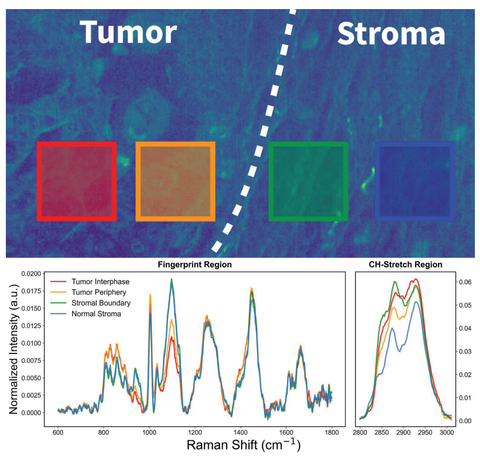
Advantages Over Traditional Spectral Analysis:

- Quantitative peak heights
- Reliable peak-center detection
- Peak discovery through deconvolution
- Better discrimination for Machine Learning analyses

CASCADE
Continuous Wavelet Transform-Adam Spectral Curve-fitting And Decomposition Engine



Molecular Imaging with BCARS



- BCARS image of clear cell Renal Cell Carcinoma (ccRCC) tissue section
- Tumor spectra indicate:
  - Increase in glycogen
    - 800 – 900 cm^{-1}
  - Decrease in collagen
    - 1050 – 1150 cm^{-1}
- Consistent with known ccRCC trends

Peak-Based Analysis

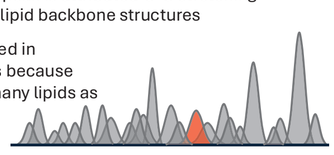
Neuronal differentiation reveals molecular localization trends

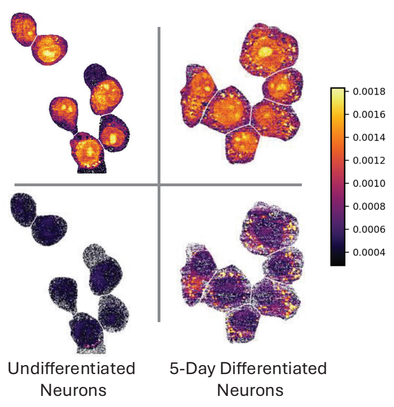
1004 cm^{-1} Peak – This peak is attributed to the amino acid phenylalanine and is associated with protein content

This peak is abundant in all biological Raman spectra, but especially in the nucleus of cells

1128 cm^{-1} Peak – This peak is attributed C-C stretching mode predominant in lipid backbone structures

This peak is upregulated in differentiated neurons because these cells produce many lipids as they begin to grow



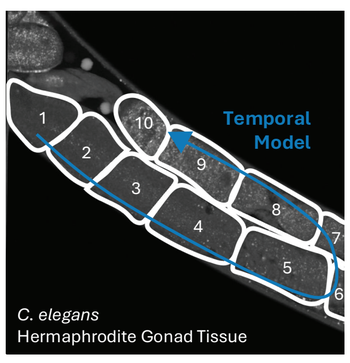


Undifferentiated Neurons

5-Day Differentiated Neurons

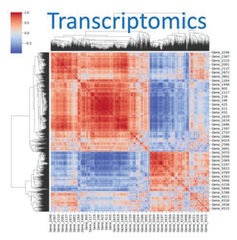
Beyond Diagnostics

BCARS could be used to diminish cost and time of multi-omic studies



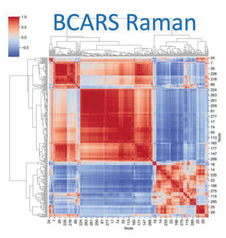
6000 Gene Correlation Map
LCM - CELseq

Months-long study



Raman Spectral Ranking
BCARS Image

20-minute image acquisition



BCARS Mirrors Transcriptomics

Tzur, Y. B.; et al. Spatiotemporal Gene Expression Analysis of the *Caenorhabditis elegans* Germline Uncovers a Syncytial Expression Switch. *Genetics* **2018,** *210* (2), 587–605

Poorna, R.; Chen, W.-W.; Qiu, P.; Cicerone, M. T. Toward Gene-Correlated Spatially Resolved Metabolomics with Fingerprint Coherent Raman Imaging. J. Phys. Chem. B 2023, 127 (25), 5576–5587.

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