Tracking How Cells Absorb Coenzyme Q_{10} – A New View with X-ray Eyes

For the first time, scientists from the University of Hamburg have successfully visualized and quantified how cells take up coenzyme Q_{10} — a vital molecule for energy production and antioxidant defense — using cutting-edge X-ray fluorescence (XRF) imaging at DESY's PETRA III synchrotron. This breakthrough not only reveals how Q_{10} enters cells but also showcases a powerful, non-invasive tool for studying the distribution of other biomolecules and drugs.

Challenge

Coenzyme Q_{10}, or Ubiquinone, is essential for cellular energy metabolism and protects tissues such as the skin from oxidative stress. Yet, its cellular uptake after supplementation has remained largely mysterious.
Traditional imaging methods like PET or SPECT can track molecules in whole organisms but lack the resolution to see inside individual cells. Other approaches, such as ICP-MS, provide that detail but destroy the sample in the process.

That's where XRF imaging at PETRA III comes in — offering both high spatial resolution and non-destructive analysis. By using the facility's intense, precisely tuned X-rays, the researchers achieved a level of sensitivity that finally made it possible to quantify Q_{10} uptake inside living cells.

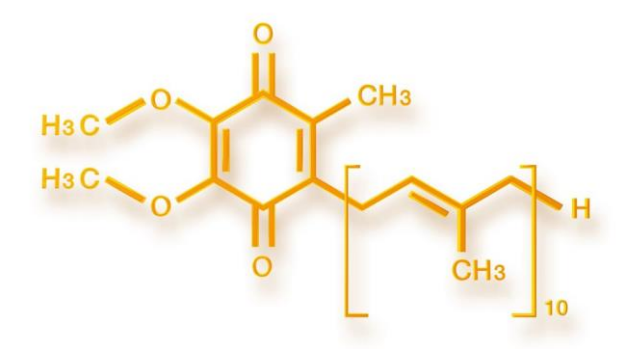

Figure 1: Molecular structure of Coenzyme Q_{10}. (*Image: Beiersdorf*)

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Illuminating the Invisible: A Synchrotron Breakthrough

To trace Q10's path, the team created an iodine-labeled version of coenzyme Q_{10} (I_2-Q_{10}) and introduced it to human skin cells (keratinocytes). After confirming that complementary XRF experiments:

- At beamline P21.1, whole-cell pellets were scanned, revealing that I_2-Q_{10} accumulated in specific regions within the individual cells — with an uptake signal roughly three times stronger than that of control samples.
- At beamline P06, sub-cellular mapping was carried out at nanometer resolution. This allowed scientists to pinpoint exactly where Q_{10} localizes within the cell, switching seamlessly between coarse and fine scans to map hundreds of cells efficiently.

The result: a clear, quantitative picture of Q_{10}'s journey into and through the cell — something no technique had achieved before.

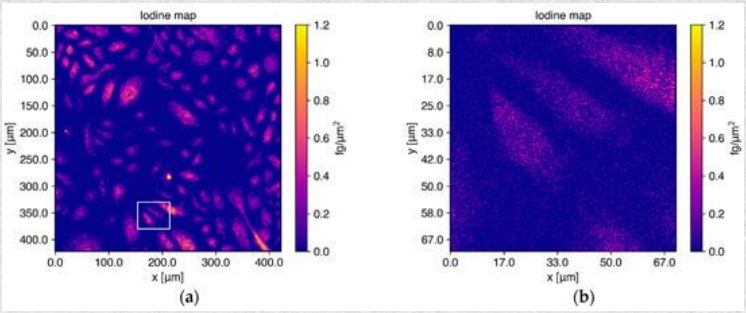

Figure 2: Elemental maps for iodine in cells using XRF at beamline P06. The coarse scan (a) shows how homogeneously distributed iodine is in the I_2-Q_{10} treated cells. The fine scan (b), indicated by the white rectangle in the coarse scan, shows a higher resolution and the distribution of the coarse scan in more detail. (*Image: DOI 10.3390/antiox11081532*)

Why It Matters

This study demonstrates that synchrotron-based XRF imaging can precisely track how biomolecules are distributed within cells, without destroying them. The approach paves the way for studying drug delivery, bioavailability, and metabolism at an unprecedented level of detail.

With high photon flux and flexible beamline setups, PETRA III offers a unique platform to explore how molecules behave inside living systems — enabling breakthroughs in both biomedical research and pharmaceutical innovation.

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