Photonics21 Press Release

New microscope uses photonics to gain insights into 'superbugs'

Scientists are building a new super-resolution microscope that uses laser light to study the inner workings and behaviours of superbugs to gain new insights into how they cause disease.

The microscope will allow scientists to peer into bacteria like Streptococcus Pneumoniae at a molecular-scale resolution – showing up objects smaller than 10,000th the thickness of a sheet of paper.

A leading cause of bacterial pneumonia, meningitis, and sepsis, Streptococcus Pneumoniae bacteria are estimated to have caused around 335,000 deaths in children aged five years and under in 2015 worldwide.

Current technologies do not allow a resolution that enables thorough studies of bacterial properties that affect disease development.

But now, this super-resolution microscope uses laser light to illuminate proteins at incredibly high resolutions, allowing scientists to gain new insights into what makes these potentially deadly bacteria so pathogenic.

Although electron microscopes can show minute detail at the atomic level, they cannot analyse live specimens: electrons can easily be deflected by molecules in the air, meaning any bacteria under inspection must be held in a vacuum. Therefore super-resolution microscopes are far more superior for biological analysis.

Called the "NANO-scale Visualisation to understand Bacterial virulence and invasiveness - based on fluorescence NANOscopy and VIBrational microscopy" (or 'NanoVIB' for short), the project will shed new light on how superbugs can cause disease, thereby providing the basis for the development of new antimicrobials to treat bacterial infections.

In a bid to understand how bacteria cause disease, the European Commission has granted this health consortium €5,635,529 via the Photonics Public Private Partnership to build this super-resolution microscope.

Ten-fold Resolution

While super-resolution microscopes already exist, the NanoVIB team proposes to make a new device with unrivalled resolution capable of revealing the intricate, detailed molecular mechanisms underlying inter-and intracellular processes and disease.

Project coordinator, Professor Jerker Widengren, said: "We expect our new microscope prototype to be a next-generation super-resolution system, making it possible to image cellular proteins marked with fluorescence emitters (fluorophores) with a ten-fold higher resolution than with any other fluorescence microscopy technique.

With the help of advanced laser, detector and microscopy technologies that will be developed in the project, super-resolution localisation patterns of specific proteins will be overlaid with light-scattering images, correlating these patterns with local structures and chemical conditions in the bacteria.

"Using laser light, this new microscope will show how bacterial proteins localise on the surface of bacteria, allowing scientists to study the interaction of the pathogen with immune and host cells.

It works based on the so-called MINFLUX concept, where infrared laser light excites fluorophore-labelled molecules in a triangulated manner – leading to an increased resolution. The user can then fine-tune the microscopic imaging to previously unimaginable resolutions.

"MINFLUX microscopy will make it possible to resolve how certain pneumococcal surface proteins are distributed on the bacteria under different cell division stages, and whether these proteins are localised in such a way that specific, extra sensitive surface regions of the bacteria, a critical step of the cell division, are protected from immune activation," said Widengren.

European Research Ecosystem

The NanoVIB team took their inspiration from a previous EU-funded project, Fluodiamon, which analysed how specific proteins are spatially distributed in breast and prostate cancer cells compared to those in corresponding non-cancer cells, demonstrating a new basis for cancer diagnosis.

"The goal of the NanoVIB project is to retrieve information, which is not within reach by any other microscopic or photonics-based technique. We will demonstrate how cellular nanoscale protein localisation patterns can be resolved, which will help us reveal bacterial disease mechanisms and are likely to be of considerable relevance for many other diseases.

"These studies could shed new light on how specific surface proteins of these bacteria are spatially distributed on the cells and provide important evidence that the virulence (capacity to generate disease) and invasiveness of these bacteria are strongly coupled to such spatial distribution patterns."

The project will conclude in 2024 and includes six partners from three countries: Kungliga Tekniska Hoegskolan (KTH), the coordinator, Karolinska Institutet (Sweden); Institut für Nanophotonik, Abberior Instruments GMBH, APE Angewandte Physik und Elektronik (Germany); and Pi Imaging Technology (Switzerland).

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About Photonics21

Photonics21 is the European Technology Platform (ETP) for photonics, a technology encompassing all products and processes around the emission, manipulation and detection of light. Photonics is integral to many industries, including the medical, healthcare, transport, manufacturing, and telecommunications sectors.

"Photonics21" was set up in December 2005 to bring the community of photonics researchers and industries together. The European Commission defined photonics as one of five European Key Enabling Technologies (KET's) in September 2009. Shortly after, the European Research & Innovation Program "Horizon 2020" invited Photonics21 to become a "Public-Private Partnership" (PPP). The "Photonics 21 Association", a legal entity under Belgium law, became the private contract partner in November 2013 in a Public-Private Partnership (PPP) in conjunction with the EU Commission.

Today Photonics21 represents more than 3000 personal members from across Europe and abroad. Our members are experts in the photonics industry, research organisations and universities who actively develop a joint photonics strategy for future research and innovation in Europe.

With the global photonics market growing from €350 Billion in 2011 to €447 Billion in 2015, Photonics remains a strong industry. The European photonics industry, estimated to be worth €70 billion, has numerous global leadership positions and employs over 300,000 people directly.

With positive growth forecasts, current industry trends like digitalisation, resource efficiency, individual and zero failure production will further drive the photonics industry.

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