ANDOR
an Oxford Instruments company

7 Questions to Ask When Choosing an Optogenetics Model:

A Neuroscientists Guide

Progress in technology, new scientific discoveries and even the birth of new fields are made possible, not only by the inquisitive minds of scientists, but also by the tools and technology at their disposal.

But at the same time, research is often limited by this same technology.

Before optogenetics, the tools used to study the neural networks of the human brain were “non-target specific” – they lacked the targeting required to study individual neurons or groups of neurons.

Instead, neuroscientists could only look at a wide region of the brain. They were not able to narrow their investigations.

So insights gleamed from these studies were limited.

Then optogenetics was born by combining optical and genetic technology. These new tools could direct light into specific regions of the brain.

This light could be used to activate or silence neurons, allowing scientists to study the resulting response.

But most optogenetics methods these days have not kept up with the demanding need of neuroscience. Exact control over the experimental conditions is still missing.

A high level of targeting, stimulating multiple regions at the same time, and illuminating neurons using different wavelengths are all needed to take neuroscientific experiments to the next level.

Why is this targeted specificity so important?

Because very specific parts of the brain are responsible for certain traits and behaviours in animals.

Tools which allow scientists to target individual neurons and specific neural regions, with fast microsecond temporal resolution, will allow detailed studies of these behaviours and why they occur.

And they'll allow more complex questions to be answered.

To paraphrase Ed Boyden, neuroscientist at MIT and recipient of the Breakthrough Prize in Life Sciences in 2015 [1],

"The basic idea is to take the brain and work backwards from its complexity, density, and high speed of operation. Then we survey all the fields of engineering, going from physics and chemistry and material science all the way to computer science and systems engineering, and figure out how to build optimal technologies that could make exact measurements of, and precise control of, brain circuits."

Hillel Adesnik of the University of California at Berkeley says one of the difficulties in some optogenetics experiments is light reaching too many cells and neurons [2],

"One thing that's been very much discussed," Adesnik says, *"is how we can control the cells one at a time, or 10 at a time, or 1,000 at a time — but extremely specifically."*

It's clear that optogenetics tools that offer well-defined temporal and spatial control of the directed light will be critical for future neuroscientific breakthroughs.

With that in mind, here are 7 questions to ask yourself and anyone else involved in the buying decision, when choosing a tool for optogenetics research:

1. **Can the tool provide exact control over defined neurons and groups of neurons?** It should be able to illuminate precisely defined patterns, with real-time accuracy. Illuminating the entire field of view (FOV) is also important.

2. **Does the tool offer high spatial and temporal resolution (ideally on the microsecond scale)?** This is needed to monitor the fast processes taking place in neurons.

3. **Does the tool combine the optogenetics method with the analytical capabilities of a microscope?** Optogenetics combined with microscopy will enable scientists to direct light at highly targeted regions. It also allows in-vivo imaging of neural activity during stimulation. This allows researchers to perform quantitative microscopy experiments with single cells.

4. **Does the tool allow sequential stimulation with high specificity?** For instance, a disadvantage of laser based systems is the inability to stimulate more than one region or cell at a time.

   And laser-based systems cannot illuminate an arbitrary mask in the imaging field.

5. **Does the tool offer complimentary illumination, allowing the use of two different wavelengths at once?** This way, you can activate one region of interest and silence a separate region of interest at the same time.

   An example would be using simultaneous inverse patterns of red and infrared light.

6. **Does the tool offer a complete transmission range?** This range should span the ultra-violet to infra-red regions of the electromagnetic spectrum.

7. **Can you use the instrument to map the connection of neurons and neural networks – allowing you to study connected neuron pairs at the same time.** Mapping also accelerates data collection, making your job easier and saving you time.

The above questions should be considered when choosing a tool for optogenetics research. Tools which offer the above capabilities are sure to be at the forefront of future neuroscientific discoveries.

The Mosaic3 available from Andor Technology offers all the desirable features for active illumination applications such as optogenetics.

It is the fastest digital micromirror device (DMD) system available and combines this technology with a microscope to offer true multi-region of interest illumination and precise, spatially targeted light control.

Mosaic3 has become an essential technology for microscopy based optogenetics and has evolved with the increasing demand of today's neuroscience experiments.

To learn more about how the Mosaic3 and Mosaic Duet systems can help you, visit

http://www.andor.com/microscopy-systems/active-illumination/mosaic

Or for a full listing of our regional sales offices, please see: www.andor.com/contact

References

[1] http://ideas.ted.com/red-light-brain-probes-and-the-future-an-enlightening-conversation/

[2] http://www.npr.org/sections/health-shots/2013/12/26/256881128/experimental-tool-uses-light-to-tweak-the-living-brain