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X-Rays as a Super Microscope

Unfortunately, many people suffer from chronic intestinal diseases that restrict them in their daily lives. Symptoms of these diseases can include diarrhea, nausea and vomiting. In many cases it is difficult to help them as the circumstances leading to the symptoms are not always clear. The persons affected can only receive helpful treatment if the disease is generally well understood and correctly diagnosed.

One type of disease that can cause the aforementioned symptoms, but is not yet well understood, involves the alteration of specific nerve cells in the bowel. One way to better understand this condition is to study the morphological changes that occur in the affected cells. For this purpose, it is necessary to take images of the cells.

Until now, the cells have been pictured by taking samples from patients via biopsy or surgery and then examining them with microscopes. The problem is that it is difficult to see such small structures in detail with normal microscopes (that means the information is incomplete) and that only very thin layers of the samples can be examined because of the low penetration power of visible light. The need for thin layers means that the sample has to be sectioned and can therefore be damaged, motivating the recording of 3D images.

In order to investigate the whole sample volume, i.e. record 3D images, light in form of X-rays can be used. Imaging is based on interaction between light and matter, more specifically between light and electrons in the matter. As X-rays have an energy more than one thousand times higher than that of visible light, they penetrate deeper into the atoms and interact with the core electrons, which only make up a small fraction of the atom's electrons. Due to this small interaction, matter is more transparent to X-rays. Having high-energy light is also accompanied by a short wavelength. The shorter the wavelength, the higher the resolution that can be achieved. Consequently, X-rays also help with resolving small features such as nerve cells and can be thought of as a super microscope.

If one does not only consider the amount of X-rays that pass through the sample, but also how they are deflected, the contrast can be increased. This works like a very powerful zoom function on a camera and makes it possible to see the nerve cells with high resolution and many details without destroying the sample.

The aim of this thesis was to record 3D high-resolution images of nerve cells by using X-rays as a "super microscope" to get started analyzing morphological alterations of these cells. This will help us learn more about chronic diseases that are caused by these changes, something that will be necessary to be able to carry out targeted treatment.

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