Magnetic Resonance Microscopy (MRM) [1]

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Magnetic Resonance Microscopy [3] (MRM) is an imaging method that allows the visualization of internal body structures. Using powerful magnets to send energy into cells, MRM picks up signals from inside a specimen and translates them into detailed computer images. MRM is a useful tool for scientists because of its ability to generate digital slices of scanned specimens that can be constructed into virtual 3D images without destroying the specimens. MRM has become an increasingly prevalent imaging technique in embryological studies. Through MRM, the first 3D human embryo images were created as part of the “Multi-Dimensional Human Embryo” project, a public database of three-dimensional embryo images.

Researchers from the Duke University Center for In Vivo Microscopy in conjunction with scientists from the National Institute for Environmental Sciences developed MRM in the early 80s. MRM represent an evolution [4] of the Magnetic Resonance Imaging (MRI) technology, which is commonly used in medicine to scan images of the body for medical diagnoses. MRM and MRI are essentially the same type of imaging technology. They both make use of powerful magnets to transmit radio frequency signals through the body. However, MRM employs a much stronger magnetic field and is conducted on a much smaller scale, providing detailed images within a range of microns. MRI machines, instead, are used to scan entire organisms.

The first image produced by MRM was of a mouse [5] brain. The scientists achieved an image whose pixels represented an area 80,000 times smaller than those generated by the large medical MRI machines. Intended for small specimens, MRM produces the clearest images of specimens that are less than seven cubic centimeters in volume. Since its invention, scientists at Duke have been gradually improving the technology by using high-strength magnets and improving upon radio frequency detectors.

MRM scans three-dimensional specimens and creates multiple images as if the sample was sliced and a photo was taken of each slice. However, the specimen remains intact. MRM detects anatomical differences between different tissues using magnets. By using highly strong magnets to send radio frequency signals into a specimen, hydrogen atoms inside the sample take up the signals and bounce them back to detectors in an imaging machine. While the sample is being scanned, the slices of digital images are created by the signals sent from the tissues to the machine. The images are sent to a computer where it is possible to visualize them. The scientist can view individual slices from multiple angles and multiple slices can be put together to create a 3D image.

The ease with which images can be created makes MRM highly valuable. Without MRM, amassing the same slices of data from tissues such as brains or embryos would require scientists to manually slice samples into pieces only a tiny fraction of a millimeter. With this manual method, scientists sometimes had to work with up to two thousand slices per sample for their studies. Furthermore, since producing a 3D image of a sample that has been sliced can take almost one year and cost up to $60,000 on average. In contrast, the total cost to do the same with MRM is about $2,000 and the quality of the images is highly improved.

MRM has proven to be a very useful tool in embryological studies, above all in the visualization of the internal structure of preserved embryos. Live, moving samples, on the contrary, do not generate clear images. MRM has been used to create images of human, mouse [5], quail, and live *Xenopus* embryos. *Xenopus* embryos are particularly compatible with MRM because the pervasive yolk [6] in developing *Xenopus* makes the inside of the embryo dense. This helps create clear images with good contrast.

MRM has shown immense value in embryological studies and will continue to be an important technology used in future embryological research. The ability of MRM to image sliced sections of samples without physically altering any specimen has proven critical to the creation of three-dimensional human embryo images. Using MRM, for instance, scientists have been able to use high quality preserved samples such as those in the Carnegie Human Embryo Collection of embryos, to produce interactive images of both human and non-human embryos.

Sources

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