Liquid crystals show promise in controlling embryonic stem cells

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Liquid crystals, the same phase-shifting materials used to display information on cell phones, monitors and other electronic equipment, can also be used to report in real time on the differentiation of embryonic stem cells.

Differentiation is the process by which embryonic stem cells gradually turn into function-specific types of adult cells or so-called "cell lineages," including skin, heart or brain cells.

The main challenge facing stem cell research is that of guiding differentiation along these well-defined, controlled lineages. Stem cells grown in the laboratory tend to differentiate in an uncontrolled manner, resulting in a mixture of cells of little medical use.

Now, UW-Madison researchers at the NSF-funded Materials Research Science and Engineering Center (MRSEC) have shown that by straining mechanically the cells as they grow, it is possible to reduce significantly and almost eliminate the uncontrolled differentiation of stem cells.

In an article in the March issue of Advanced Functional Materials, the team reports on a liquid crystal-based cell culture system that promises new ways of achieving real-time control over interactions between synthetic materials and human embryonic stem cells, including the possibility of straining embryonic stem cells as they grow.

"Stem cells tend to be smaller and have a slightly more compact shape

than the differentiated cells," says chemical and biological engineer Sean Palecek. "Differentiated cells appear to be much more spread and they appear to exert different levels of force on the matrix in which they are grown. That force can be read to a liquid crystal. Through simple changes of liquid crystal texture and color, our cell culture system is able to report, in real time, the cell interactions with the underlying support on which they are grown."

Currently, researchers have several methods of monitoring cell differentiation. The easiest, says Palecek, is to just look at the cells and use cell morphology as a cue. A more accurate method uses molecular markers. Antibodies are placed against these markers to determine if they bind to the cell. That system, while more accurate, does not provide real time data and cells often have to be killed in order to analyze the markers.

"This newly devised cell culture system enables a new paradigm in stem cell research," says chemical and biological engineer and MRSEC Director Juan de Pablo. "Ultimately, we hope to use liquid crystalline materials to transmit desired sets of physical and chemical cues to stem cells so as to control their differentiation, as well as report back specific responses of the cells or tissue.

"This research is also significant as an example of our unique effort to integrate advanced materials engineering and embryonic stem cell research, an effort that will help accelerate the rate at which the benefits of stem-cell based therapies are brought to society," de Pablo adds.

In addition to Palecek and de Pablo, authors of the paper include former post-doctoral researcher Nathan Lockwood, graduate student Jeff Mohr, researcher Lin Ji, School of Veterinary Medicine (ophthalmology) and biomedical engineer Christopher Murphy, and chemical and biological engineer Nicholas Abbott.

Source: University of Wisconsin, by James Beal