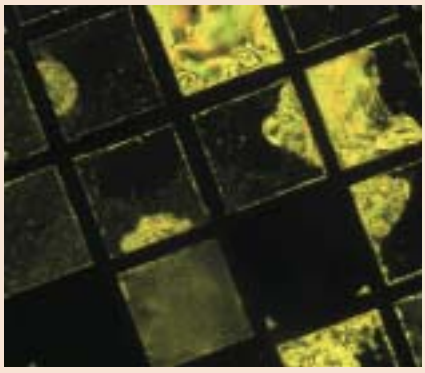
Liquid crystals track stem cells

BIOMATERIALS

Liquid crystal displays have become integral to many electronic devices, such as mobile phones, personal computers, and medical monitors. Their use in biological systems is far less widespread. Now researchers from the University of Wisconsin-Madison have provided evidence of their potential in the bioengineering arena by showing that liquid crystals can monitor the growth of embryonic stem cells [Lockwood *et al.*, *Adv. Funct. Mater.* (2006) **16**, 618].

Human embryonic stem cells gradually turn into useful, function-specific cells through a process called differentiation. Differentiated cells and stem cells exert different forces on the matrix in which they are grown, owing to characteristic variations in their size and shape. If these forces are translated to a liquid crystal surface, differentiation should be detectable as simple changes in color and texture.

The researchers put this hypothesis to the test by culturing human embryonic stem cells on interfaces of a thermotropic liquid crystal that had been decorated with thin films of an extracellular matrix. The cells survived for up to 12 days on the liquid crystal substrates. Their



Courtesy of the University of Wisconsin-Madison.

interactions with the underlying matrix could be seen as changes in the liquid crystal's appearance when observed with polarized light microscopy.

Juan J. de Pablo accepts that the group's use of liquid crystalline materials is relatively novel. However, he believes that the integration of advanced materials engineering with cell biology has many advantages. "The use of liquid crystals as sensors for biological processes is extremely promising. It is an inexpensive, reliable technology," he says.

Existing methods of monitoring cell differentiation involve simply looking at the cells or using molecular markers that bind to the cellular targets. This latter method can be accurate, but does not provide real-time data.

In addition to gaining data from cell systems, de Pablo would like to see if liquid crystals can influence cell behavior. Stem cells grown in laboratory environments will often differentiate in an uncontrolled manner, resulting in a mixture of cells that are of little medical use. Imposing strains on the cells can control differentiation. Liquid crystal substrates could be used to exert this mechanical deformation.

Research will also need to be done to check that liquid crystalline monitors are not toxic, de Pablo notes. "This is a complex, multicomponent system where many variables come into play, for example, temperature, humidity, composition of media used to grow the cells, and composition of the liquid crystals. Each of these needs to be examined independently," he says.

Paula Gould

Carbon nanotubes help bones grow

BIOMATERIALS

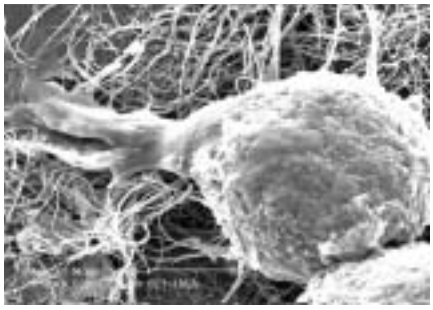
Carbon nanotubes (CNTs) should be ideal candidates for bone bioengineering because of their high strength and flexibility. However, questions have been raised about their biocompatibility. Researchers at the University of California, Riverside (UCR) have shown that bone cells can grow and multiply on a CNT scaffold, given sufficiently pure starting materials [Zanello *et al.*, *Nano Lett.* (2006) **6**, 562].

Current medical treatments for bone defects generally involve replacement of lost bone with an artificial material. Tissue engineering offers the chance to regrow missing bone by culturing new cells on synthetic scaffolds or live prostheses. Unlike many potential bone scaffold materials, CNTs are not biodegradable. A nanotube scaffold would consequently provide an inert platform on which cells could proliferate and deposit new living bone material. An implanted CNT scaffold could also reinforce the mechanical properties of damaged bone tissue.

The UCR team is the first to show that CNTs can function as such a scaffold. They cultured rat bone cells on single- and multi-walled nanotubes, some of which had been modified to contain electrically-charged chemical groups. The biocompatibility of each system was assessed according to the multiplication of osteoblasts (bone-forming cells), cell morphology, and the formation of hydroxyapatite crystals, which are formed during bone mineralization. They found that neutrally charged CNTs provide the best environment for bone growth. Growth was reduced on nanotube scaffolds that had been engineered to have a net positive or negative charge. The results also suggest that cell shape can be controlled by the choice of single- or multi-walled nanotube scaffolds.

The results are preliminary, but promising, says Laura P. Zanello. "Most previous work combining CNTs with living cells has reported cytotoxicity. Even though we found reduced bone cell proliferation in our CNTs, we were lucky to have highly purified nanotubes. This has significantly improved our ability to grow these cells."

Zanello hopes to continue the research by extending the length of time that cell cultures are maintained,



Single osteoblasts on multi-walled CNTs. (Credit Laura Zanello.)

and using the topography of CNTs to redirect bone deposition. Both these steps should be taken before moving the work into animal models, she says. Possible interactions between the human immune system and CNTs should also be investigated prior to clinical use, given that the scaffold would remain *in situ*, she says.

Paula Gould