Advances in Tissue Engineering
August 11 to 14, 2004, Rice University, Houston, TX
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This was an excellent conference with 40 invited speakers over 4 days. Nearly all the presentations were excellent. I attended the conference to gain insight into what topics should be included in our undergraduate biomedical engineering program (particularly in our biology, physiology and biomaterials courses). What follows are my conclusions:

Tissue engineering (also being called regenerative medicine) is based in the interaction of cells (often stem cells from fetal or adult sources), scaffolds (or substrates) and signals (growth factors, mechanical stimuli, etc).

The physical structure and chemical nature of the extracellular matrix (ECM) is critical for natural and engineered cell development, differentiation, maintenance, etc.

Clinical practice appears to be significantly ahead of rigorous science and systematic engineering in this field. In general, cells exhibit remarkable *in vivo* plasticity given the opportunity. However, driving cells down specific developmental pathways by applying particular endogenous manipulations is generally beyond the current state-of-the-art. Tissue engineering generally involves both blocking "normal" scar (fibrotic) healing and activating latent regenerative mechanisms. An example of this involves implantation of SIS or AlloDerm in the shoulder and abdominal wall where it appears to guide the regeneration of site appropriate tissues.

Here are topics discussed organized by academic subject (courses):

Specific Topics – Biology

Cell surface receptors (including SMAD's) and receptor pathways
Control of gene expression
Identification of cell types based on surface markers (and its limitations)
Embryonic development at the cellular level including the role of apoptosis
Evolution and the conservation of genes among species
Size scales and the important of substrate micro-texture to cell response.
Cell cycle and its control

Specific Topics – Physiology

Emphasis on the tissues and cells that make up organs.
Specific coverage of growth factors (VEGF, BMP's, PDGF, etc. (also fetal calf serum))
Fetal and adult stem cells (including ESC's, HSC's, MSC's, MDSC's & ADSC's)
Chemotaxis
Inflammatory response
Immune system (including the role of dendritic cells)

Specific Topics – Biomaterials

ECM components including:

- Collagen types (particularly I, II & IV) and their distribution in different tissues
- Proteoglycans and glycosaminoglycans
- Fibronectin, laminin & tenascin
- Hyaluronic Acid

Polymers (particularly hydrogels and biodegradable polymers like PLGA)
ASTM (and other) standards for tissue characterization
Use of biologics as biomaterials (ECM from bladder or intestinal submucosa (SIS)).
Mechanisms of angiogenesis
Role of mechanical forces on cell behavior and tissue structure
Use of demineralized bone and/or bone marrow in treating non-unions.
Use of animal models in biomaterials research (including SKID, nude & knockout mice)
Cell fusion versus cell differentiation explanations for tissue regeneration observations
Cell culture and bioreactor issues
OP-1, InFuse, AlloDerm, Chrysalin & other specific products

Specific Topics – Design

How the FDA regulates drugs, devices, biologic and combination products.
How tissue for transplant is regulated (by HRSA not the FDA if not banked).
Gene microarrays and determination of gene expression profiles
Use of flow cytometry to sort cells.
Gene delivery techniques
3D & Micro-3D printing (stereolithography) techniques

Specific Topics – Medical Imaging (or elsewhere)

Modern microscopic imaging techniques (optical coherence tomography, fluorescence imaging, confocal microscopy (including scanning laser and multiphoton devices)).