Why do we use bioenergy?

We need to reduce the amount of fossil fuel we burn to meet carbon reduction goals.

- **Renewable source -** Bioenergy is a low-carbon renewable energy that we can use to replace carbon intensive fossil fuels.
- **Hard-to-reach sectors -** We can use biomass fuels in cases where few renewable energy options exist, such as fuel for aeroplanes, ships and trucks.
- **Carbon capture -** We may be able to use bioenergy with carbon capture technology to remove CO_2 from the atmosphere. Many of the future scenarios for climate-friendly energy systems rely on the use of this technology.

Bioenergy and climate change

For bioenergy to play this essential role, we need to produce and use it sustainably. Bioenergy must significantly reduce greenhouse gas emissions.

The use of organic fuel to create bioenergy releases carbon dioxide (CO_2) into the air. This is offset by new plants that consume that CO_2 during growth. But improper sourcing and processing of biomass for energy can also pose a risk to our climate.

What are biomaterials?

Hydrogel sealants may allow pain-free dressing changes for patients with burns. Grinstaff lab, Boston University

Biomaterials play an integral role in medicine today—restoring function and facilitating healing for people after injury or disease. Biomaterials may be natural or synthetic and are used in medical applications to support, enhance, or replace damaged tissue or a biological function. The first historical use of biomaterials dates to antiquity, when ancient Egyptians used sutures made from animal sinew. The modern field of biomaterials combines medicine, biology, physics, and chemistry, and more recent influences from tissue engineering and materials science. The field has grown significantly in the past decade due to discoveries in tissue engineering, regenerative medicine, and more.

Metals, ceramics, plastic, glass, and even living cells and tissue all can be used in creating a biomaterial. They can be reengineered into molded or machined parts, coatings, fibers, films, foams, and fabrics for use in biomedical products and devices. These may include heart valves, hip joint replacements, dental implants, or contact lenses. They often are biodegradable, and some are bio-absorbable, meaning they are eliminated gradually from the body after fulfilling a function.

How are biomaterials used in current medical practice?

Doctors, researchers, and bioengineers use biomaterials for the following broad range of applications:

- **Medical implants**, including heart valves, stents, and grafts; artificial joints, ligaments, and tendons; hearing loss implants; dental implants; and devices that stimulate nerves.
- **Methods to promote healing of human tissues**, including sutures, clips, and staples for wound closure, and dissolvable dressings.
- **Regenerated human tissues**, using a combination of biomaterial supports or scaffolds, cells, and bioactive molecules. Examples include a bone regenerating hydrogel and a lab-grown human bladder.
- **Molecular probes and nanoparticles** that break through biological barriers and aid in cancer imaging and therapy at the molecular level.
- **Biosensors** to detect the presence and amount of specific substances and to transmit that data. Examples are blood glucose monitoring devices and brain activity sensors.
- **Drug-delivery systems** that carry and/or apply drugs to a disease target. Examples include drug-coated vascular stents and implantable chemotherapy wafers for cancer patients.

What technologies are NIBIB-funded researchers developing with biomaterials?

NIBIB funds research that aims to address the function and biocompatibility of biomaterials.

Biomaterials designed for function

Bioengineers measure the function of a biomaterial by how well it performs a specific action and how it will be used. A wound healing system must promote skin growth and blood vessel formation. Bone replacement material must support cell attachment and facilitate bone growth.

A new family of fibrous protein systems

Stem cells are not specialized, so they have the potential to transition into any specific kind of cell under the right conditions. Biomaterials can be used to control stem cell fate and function. NIBIB-funded researchers are working to combine silk with tropoelastin, a highly elastic and dynamic structural protein to construct a panel of protein biomaterials. These materials must mimic the elasticity of diverse tissue structures and, consequently, control biological function, particularly the differentiation of stem cells.

A patch for use as a lung sealant

Sealants and patches made from biomaterials allow damaged tissue to regenerate and heal. NIBIB-funded researchers are exploring the use of alginate, derived from brown algae, as a sealant and therapeutic patch to treat lung leaks resulting from surgery, injury, or conditions such as pneumonia and cystic fibrosis. After the alginate is freeze-dried, it is applied to the wound and rehydrated from the body's own water. Preliminary tests are promising, showing the patch can withstand lung-like pressures, effectively treat lung leaks, and aid in lung tissue regeneration.