

Student 7 – Bioengineering Answer Sheet

Question 1

Explain the differences between genetic engineering, tissue engineering, and biomedical imaging in bioengineering. Provide examples of applications for each approach.

Answer:

Genetic engineering is about changing an organism's DNA to give it new traits or fix genetic problems. This can be done using gene editing tools like CRISPR-Cas9, gene therapy, or recombinant DNA technology. For example, scientists use genetically engineered bacteria to make insulin, create crops that resist diseases, or treat genetic illnesses such as cystic fibrosis.

Tissue engineering deals with building biological substitutes that can repair or replace damaged tissues. It uses a mix of cells, biomaterials, and biochemical factors to make things like skin grafts for burn victims, artificial cartilage for joints, or even lab-grown organs for transplants.

Biomedical imaging includes various techniques to see inside the body without surgery. Methods like MRI, CT scans, ultrasound, and PET allow doctors to diagnose tumors, check how organs are working, and help guide surgeries.

In summary, genetic engineering works at the DNA level, tissue engineering constructs new tissues or organs, and biomedical imaging provides non-invasive ways to look inside the body for diagnosis and research.

Question 2

Describe the structure and function of a typical biosensor. Why are biosensors important in medical diagnostics?

Answer:

A biosensor is a device that detects specific substances using a biological component (like an enzyme, antibody, or DNA fragment) and a transducer. The biological part binds to the target molecule, and the transducer changes this event into a measurable signal—such as an electrical current.

Key parts of a biosensor:

- **Bioreceptor:** Binds specifically to the target (e.g., glucose oxidase for glucose).
- **Transducer:** Turns the binding event into a signal (like an electrode measuring current).

- **Signal Processor:** Amplifies and displays the result.

Biosensors are essential in medical diagnostics because they can quickly and accurately detect things like blood sugar, hormones, or disease markers. Examples include glucose meters for diabetes, pregnancy tests, and wearable health monitors. Their ability to give fast, point-of-care results helps doctors make better decisions and supports personalized medicine.

Question 3

Discuss the ethical considerations and societal impacts of genetic modification in humans.

Answer:

Changing human genes brings up important ethical and social questions. The biggest concern is safety—unexpected mutations or side effects could be harmful. There’s also the issue of fairness: if only wealthy people can afford genetic therapies, it could widen social inequality.

Consent is crucial, especially for changes that affect future generations who can’t agree to them. We don’t know all the long-term effects, and some changes might be permanent. There are also worries about “designer babies,” where genes are changed for non-medical reasons, raising questions about what traits should be altered and who decides.

Society could also be affected if people with unmodified genes are stigmatized, or if ideas about what’s “normal” or a “disability” change. To handle these challenges, we need strong regulations, open public discussions, and ethical oversight.

Question 4

Explain the concept of biomaterials and discuss their advantages and limitations in medical implants.

Answer:

Biomaterials are materials—either natural or synthetic—designed to work with the body for medical uses like implants, prosthetics, or scaffolds for tissue growth. Examples include titanium for joint replacements, hydroxyapatite for bone repair, silicone for heart valves, and various polymers.

Advantages:

- **Biocompatibility:** They’re made to minimize immune reactions and blend with body tissues.

- **Durability:** Built to last a long time inside the body.
- **Versatility:** Can be customized for different mechanical, chemical, or biological needs.

Limitations:

- They might be rejected or cause inflammation.
- There's a risk of infection where they're implanted.
- They can wear out or degrade over time.
- They can't always fully mimic the function of natural tissues.

Research is ongoing to create smarter biomaterials that heal better, resist infection, and integrate perfectly with the body.

Question 5

Describe the principles of tissue engineering and how stem cells are used to regenerate damaged tissues.

Answer:

Tissue engineering uses living cells, scaffolds, and growth factors to fix or replace damaged tissues. The process usually involves:

1. Taking stem or progenitor cells from the patient or a donor.
2. Placing these cells onto a biodegradable scaffold that acts like the body's natural matrix.
3. Growing the construct in a bioreactor with the right chemical and mechanical signals.
4. Implanting the engineered tissue into the patient, where it matures and connects with the body's own tissue.

Stem cells are especially important because they can turn into many different cell types and can keep dividing. By controlling their environment, scientists can guide them to become specific tissues like heart muscle or cartilage. This approach is used for regenerating skin for burn patients, repairing heart tissue after a heart attack, and even growing organs for transplants.