SCHEME and SOLUTION

Internal Assessment Test 3 –August 2024

BIOLOGY FOR COMPUTER ENGINEERS - BBOC407

1. Explain the mechanism and bioengineering solutions for muscular dystrophy and osteoporosis. (10m)

- The musculoskeletal system (locomotor system) provides body with:

movement , stability , shape and support.

- It is subdivided into 2 broad systems:

1. Muscular system
2. Skeletal system

- One of the most common musculoskeletal conditions is Osteoporosis.
- Arthritis is also very common.
- Muscular dystrophy is a group of diseases that cause progressive weakness and loss of muscle mass

Awareness is increasing that (5m):

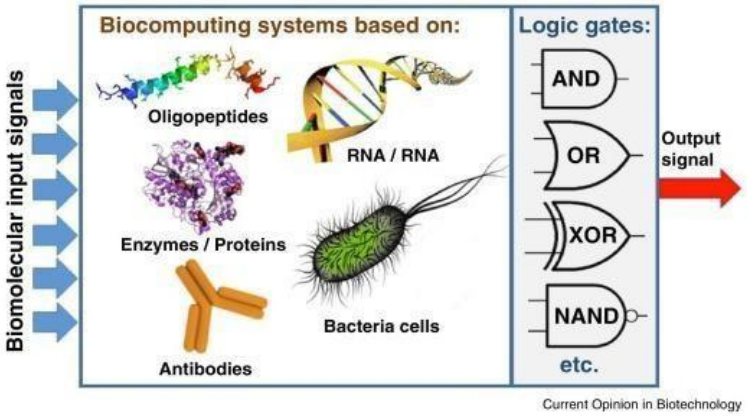
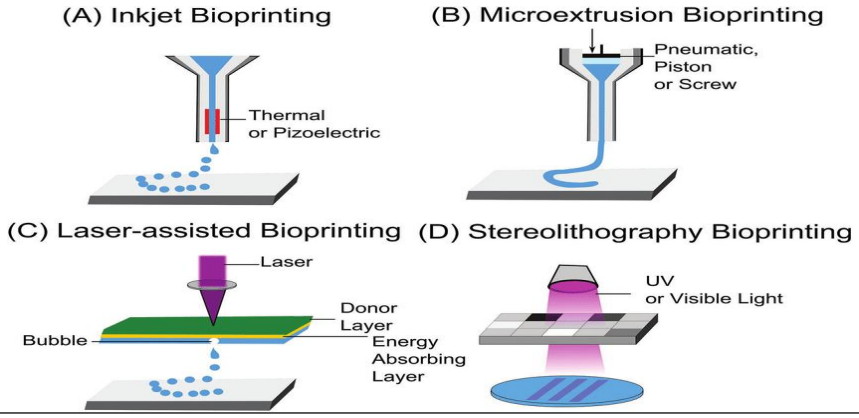
- Osteoporosis is a major complication of Duchenne muscular dystrophy (DMD) and
- Its treatment, requires monitoring for early diagnosis and intervention to prevent clinically important sequelae.

➢ The traditional method of fabricating 3D muscle constructs first developed more than 25 years ago. (5m)
➢ It involves casting myogenic cells within a cylindrically shaped collagen-I gel.
➢ In this system, cell-mediated gel, compaction and remodeling result in generation of passive stress within the gel.
➢ This, promotes the fusion of myoblasts (muscle cells) into myotubes(multinucleated cells chain) and myotube alignment.
➢ Alternatively, myoblasts can be cultured on laminin- or hydrogel-coated dishes.
➢ Till myotubes assemble into a cylindrical tissue construct & are attached at the ends to premade suture anchors.
➢ Cell alignment within 3D constructs increases fusion efficiency.
➢ In addition to collagen I, different natural hydrogels and their derivatives can support 3D growth and fusion of myogenic cells.
➢ Hydrogels have been dominant muscle-engineering scaffold (provide structural support for cell attachment and tissue development).
➢ Also, studies of muscle repair have mainly utilized:

- acellular natural scaffolds
- porous matrices made of degradable polymeric materials or
- scaffold-free myoblast sheets.

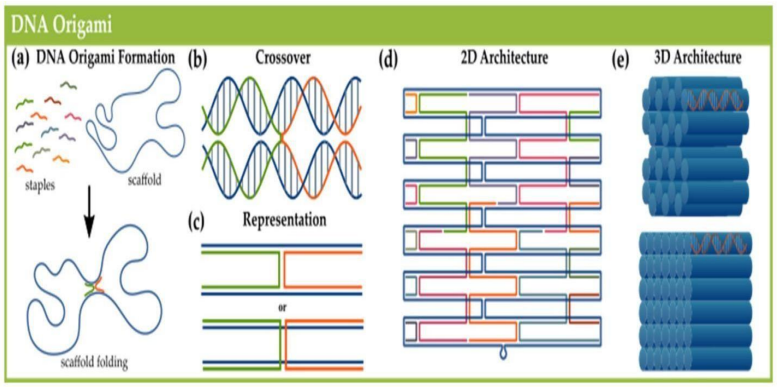
2. Explain DNA biocomputing

➢ A computer that uses components of biological origin (like molecules of DNA) instead of electrical components.
➢ To understand & model, healthy or sick human body, researchers and doctors are utilizing more & more tools and techniques.
➢ This trend is pushing for a new field called Biomedical Computing which is a frontier

	among: (5m) ■ signal processing, ■ pattern recognition, ■ optimization, ■ nonlinear dynamics, ■ computer science and biology, ■ chemistry and medicine. ➢ Computing process use synthesized biological components to store and manipulate data. ➢ The result is small, faster computing processes that operates with great accuracy. ➢ The main application is in disease prediction and disease diagnosis. (5m)  Current Opinion in Biotechnology
3.	Write a note on bio printing techniques and materials. (10m) ➢ Bio printing is defined as the printing of structures consisting of living cells, bio materials and active bio molecules ➢ A solution for the organ shortages ➢ Significant potential of drug delivery & cancer studies ➢ Controllable microstructures with a high degree of reproducibility and scalability. (5m) Hydrogels: ➢ Hydrogels are attractive materials for bio printing. ➢ They are enormous three dimensional network of polymer chains holding a mass of water Types: (5m) 

4. What is DNA origami? Explain the process of DNA origami. (10m)

- DNA origami is the nanoscale folding of DNA to create arbitrary 2-D and 3-D shapes at the nanoscale.
- The current method of DNA origami was developed by Paul Rothemund at the California Institute of Technology.
- The process involves folding of a long single strand of viral DNA aided by multiple smaller "staple" strands.
- These shorter strands bind the longer in various places, resulting in the formation of a pre-defined 2-D or 3-D shape.
- Examples: a smiley face and a coarse map of China and the America, and many 3-D structures such as cubes.
- To produce a desired shape, images are drawn with a raster fill of a single long DNA molecule.
- This design is then fed into a computer program that calculates the placement of individual staple strands.
- Each staple binds to a specific region of the DNA template.
- The DNA is mixed, then heated and cooled.
- As the DNA cools, the various staples pull the long strand into the desired shape.



- Designs are observable via several methods, including: (5m)

- Electron microscopy.
- Atomic force microscopy, or fluorescence microscopy when DNA is coupled to fluorescent materials

- Bottom-up self-assembly methods are considered as alternatives.
- It offers cheap, parallel synthesis of nanostructures under relatively mild conditions.
- Software was developed to assist this process using CAD software.

- Ex: caDNAno is an open source software for creating such structures from DNA.

- The use of software has increased the ease of the process & drastically reduced the errors made by manual calculations.

Applications: (5m)

- Many potential applications, include:

- ✓ enzyme immobilization.
- ✓ drug delivery systems and
- ✓ Nano technological self-assembly of materials.
- ✓ DNA is not the natural choice for building active structures for nanorobotic applications,

	due to its lack of structural and catalytic versatility ✓ Several papers suggest the possibility of molecular walkers on origami and switches for algorithmic computing. ✓ Following is application conducted in laboratories with clinical potential. ■ Long strands of DNA are folded into a complex scaffold of staple strands having 200–300 nucleotides. ■ This lead to formation of a complex structure with nanoscale dimensions. ■ These are in their preliminary developmental stages. ■ Theoretically, DNA origami has potential to contribute in diagnosis and drug delivery areas. ■ Cancer therapy and diagnosis is one such potential domain where DNA origami showed significant anticancer efficacy.
5.	Write a note on how heavy metals affect health. How biomining of microbial surface adsorption happens? (10m) ✓ **Biomining** is the process of using microorganisms (microbes) to extract metals of economic interest. (5m) ✓ Biomining techniques may also be used to clean up sites that have been polluted with metals. ✓ Valuable metals are commonly found in solid minerals. ✓ Microbes can oxidize metals, allowing them to dissolve in water. ✓ This is the basic process behind most biomining. ✓ **Another,** biomining technique uses microbes to break down the surrounding minerals. ✓ This makes it easier to recover the metal of interest directly from the remaining rock. ✓ Most current biomining operations target valuable metals like: copper, uranium, nickel, and gold, commonly found in sulfidic (sulfur-bearing) minerals. ✓ Other metals, like gold, are not directly dissolved by this microbial process, but minerals surrounding these metals are dissolved. ✓ When the metal of interest is directly dissolved, the biomining process is called "bioleaching" ✓ When the metal of interest is made more accessible or "enriched" in the material left behind, it is called "biooxidation" ✓ Both processes involve microbial reactions with necessary nutrients, like oxygen, occur together. ✓ Biohydrometallurgy is a natural processes of interactions between microbes and minerals. ✓ It extracts valuable metals from a low-grade ore with the help of microorganisms such as bacteria or archaea. (5m) A) Heavy metal ions adsorption process: --- The metal ions of waste water adhere to surface of nanoporous adsorbents. --- The adsorption process could be selective for one or more metals than others. --- The regeneration process could be achieved using a desorbing agent. B) Various modification techniques (i.e., nitrogenation, oxidation, and sulfuration): --- Are used to functionalize carbon with different functional groups. --- Functionalization enhances adsorption capacity and stability.
6.	Write a note i.Self-healing bio concrete ii. Bioremediation. ✓ Bio-concrete is a self-healing form of concrete designed to repair its own cracks. ✓ To heal cracks in the concrete, Jonkers chose bacteria, that produce limestone ($CaCO_3$ precipitation) on a biological basis. ✓ The positive side-effect is: the bacteria consumed oxygen, which in turn prevents internal corrosion of reinforced concrete ✓ This bacteria do not pose a risk, since they can only survive under alkaline conditions

inside concrete.

- ✓ Jonkers and his team of researchers developed 3 different bacterial concrete mixtures:

self-healing concrete, repair mortar and a liquid repair system.

- ✓ The repair mortar and liquid system: used when acute damage has occurred on concrete elements.
- ✓ In self-healing concrete: bacterial content is integrated during construction & is complex.
- ✓ Bacterial spores are encapsulated within 2-to 4-millimeter wide clay pellets.
- ✓ Then added to the cement mix with separate nitrogen, phosphorous and a nutrient agent.
- ✓ This approach ensures that bacteria remains dormant in concrete for up to 200 years.
- ✓ Contact with nutrients occurs only if water penetrates into a crack – and not while mixing cement.
- ✓ Thus, the need for expensive and complex manual repairs is eliminated (5m).

- ✓ Bioremediation is a biotechnical process. It is a type of waste management technique which involves use of organisms to remove or utilize the pollutants from a polluted area.
- ✓ Bioremediation is of 3 types : (5m)

1. Biostimulation:

- ■ As the name suggests, bacteria is stimulated to initiate the process.
- ■ The contaminated soil is first mixed with special nutrients substances.
- ■ It stimulates growth of microbes, resulting in efficient and quick removal of contaminants.

2. Bioaugmentation:

- ■ At times, microorganisms are required to extract the contaminants.
- ■ For example – municipal waste water.
- ■ In these cases, the process of bioaugmentation is used.
- ■ One major drawback: It almost becomes impossible to control growth of microorganisms in the process of removing contaminant.

3. Intrinsic Bioremediation:

- ■ It is most effective in soil and water because these always have a high probability of being contaminated.
- ■ It is mostly used in underground places like underground petroleum tanks.
- ■ In such place,It is difficult to detect a leakage and Contaminants and toxins enter through the leaks and contaminate the petrol. Thus, only microorganisms can remove the toxins and clean the tanks.
- ■ Microorganisms are utilized here because of their ability to degrade pollutants via biochemical pathways.

	✓ Immobilization of microbial cells and enzymes by adsorption is done through their physical interaction with surface of water-insoluble carriers. ✓ This method, is quick, simple, eco-friendly and cost-effective. ✓ Bioremediation helps to: ■ clean up water sources, ■ create healthier soil, and ■ improve air quality around the globe. ✓ But Excavation-based remediation processes, can be disruptive.