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NANOBIOTECHNOLOGY IN DRUG DELIVERY: INNOVATIONS, CHALLENGES, AND FUTURE DIRECTIONS

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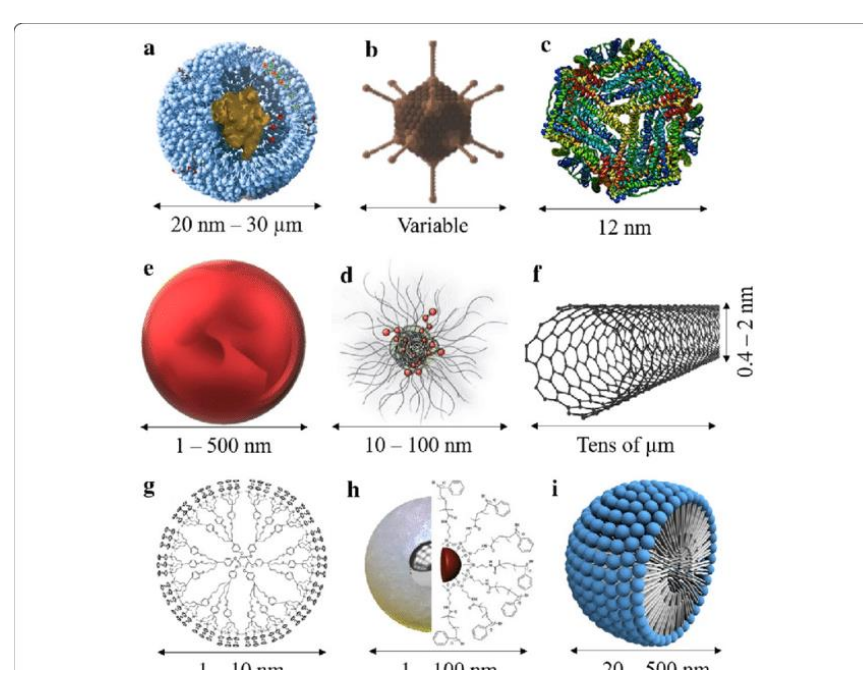
Abstract: This review highlights the role of nanobiotechnology in advancing drug delivery through engineered nanoscale carriers. It discusses key platforms, targeting strategies, and responsive systems, while addressing clinical applications, regulatory aspects, and challenges such as toxicity and scalability.

• Introduction

Nanobiotechnology merges nanotechnology and biotechnology to address the limitations of traditional drug delivery. By designing nanoscale carriers with biocompatible materials, this field enables precise, efficient, and safe therapeutic transport to diseased tissues.

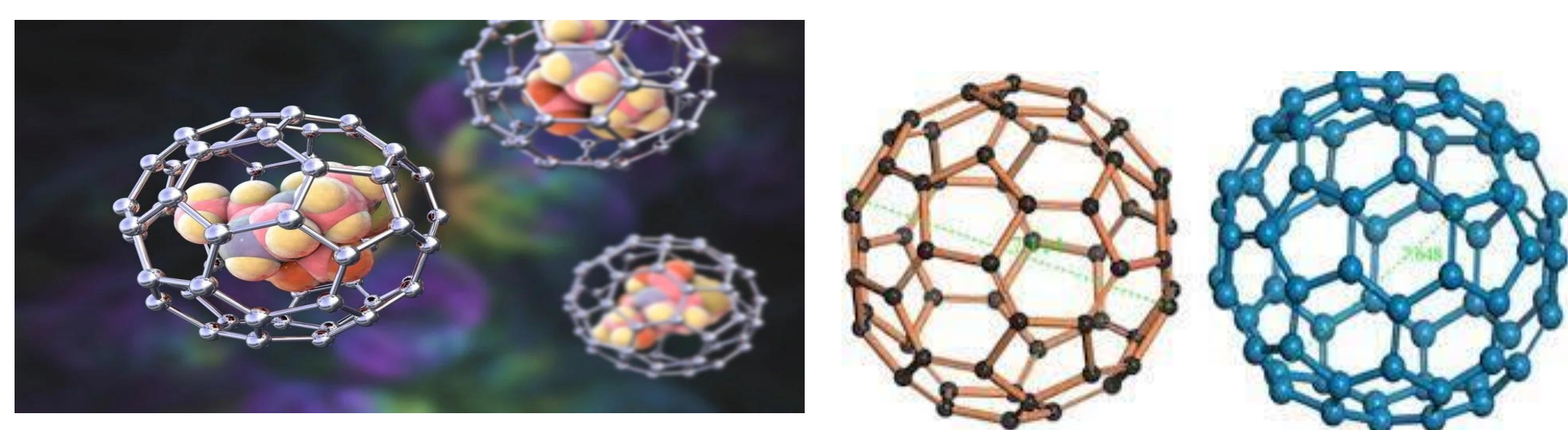
• Advantages and challenges

- ✓ Precision targeting
- ✓ Controlled drug release
- ✓ Minimized side effects
- ✓ Enhanced therapeutic index



• Nanobiotechnological platforms

- **liposomes** – as phospholipid vesicles for hydrophilic and lipophilic drugs;
- **polymeric nanoparticles** – biodegradable, customizable systems;
- **dendrimers** – highly branched, multivalent carriers;
- **biologically derived vesicles** – exosomes and other natural nanocarriers.



• Mechanisms of Action

- **Encapsulation** of drug delivery
- **Targeted delivery** to specific tissue or cell types
- **Controlled and sustained release profiles**

• Conclusions

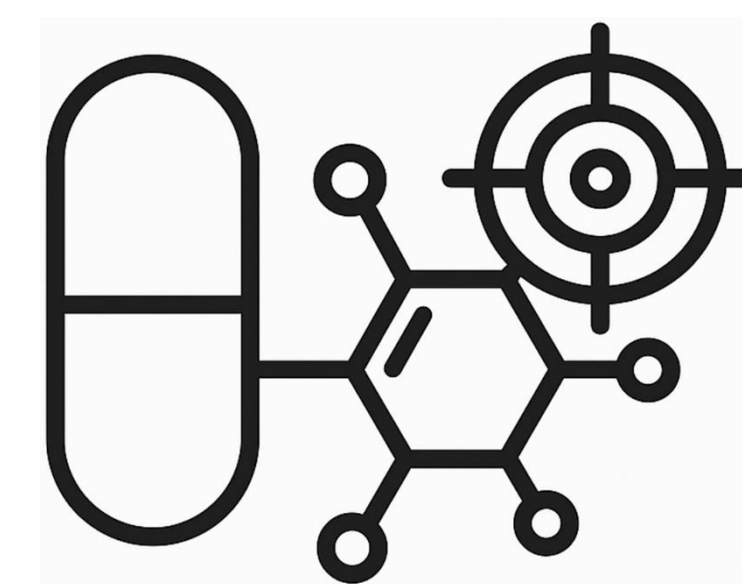
Nanobiotechnology offers a promising future for precise, efficient drug delivery. Its integration into clinical practice depends on overcoming current challenges related to safety, scalability, and regulatory approval.

• Targeting Strategies

- Passive targeting – enhance permeability and retention;
- Active targeting – ligand-functionalized nanoparticles bind to specific cell receptors;
- Stimuli-responsive systems – Triggered by pH, enzymes, or temperature changes in pathological environments

• Clinical Applications

- Cancer therapy
- Neurological disorders
- Antimicrobial delivery
- Gene therapy



• Regulatory and safe considerations

- Toxicity and immunogenicity concerns
- Challenges in reproduction and consistency
- Need for harmonized regulatory biochemical pathways

• Emerging Challenges & Future Directions

- Scalability of production for clinical translation
- Personalization of nanocarrier systems
- Integration with diagnostic technologies for theranostics (therapy & diagnostic)