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Nanoparticles and Biomarkers for Disease Diagnosis and Treatment

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1. Background-Aim

- The integration of nanotechnology and biomarker discovery offers transformative potential for disease diagnosis and treatment. Nanoparticles, enhance diagnostic and therapeutic approaches, while biomarkers provide critical insights into disease mechanisms and personalized medical care.

- **Nanoparticles** (NPs) are tiny particles with unique properties due to their small size (1-100 nm), allowing them to interact effectively with biological systems. They can be activated with antibiotics, directed towards specific target cells and used in diagnosis by targeting specific biomarkers.
- **Biomarkers** are biological molecules used as indicators of disease processes or therapeutic responses.

Aim: Highlight the role of nanoparticles in enhancing disease diagnosis and drug delivery, specifically by targeting biomarkers.

Categories of Biomarkers

- **Genetic Markers:** changes in DNA (mutations, polymorphisms) associated with predisposition to certain diseases or response to specific treatments.
  ex: BRCA1/2 for breast cancer
- **Protein Markers:** levels or changes in specific proteins that can indicate the presence of a disease.
  ex: PSA for prostate cancer
- **Metabolic Markers:** changes in the levels of specific metabolites that reflect metabolic disorders. ex*:* Blood glucose for diabetes

Types of Nanoparticles

- **Metallic Nanoparticles:** made from metals such as gold, silver, and iron. Widely used in diagnostic (MRI) and therapeutic applications.
- **Polymeric Nanoparticles:** made from biocompatible polymers and often used for drug delivery.
- **Liposomal Nanoparticles:** made from lipids and primarily used for drug delivery.
  Dendrimers: highly branched, molecularly structured polymers, ideal for drug and gene delivery.

Nanoparticles in medical applications

Disease Diagnosis

- **Imaging Modalities:** enhance imaging techniques such as MRI, CT, PET, and fluorescence imaging.
- **Biosensors:** rapid and accurate detection of biomarkers.
- **Point-of-Care Diagnostics:** rapid diagnostic tests for quick detection.

Disease Treatment

- **Drug Delivery Systems:** controlled release and targeted delivery of drugs, reducing side effects and improving therapeutic outcomes.
- **Photothermal and Photodynamic Therapy:** destroy of diseased cells through heat or light.
- **Gene Therapy:** action as carriers for delivering genetic material

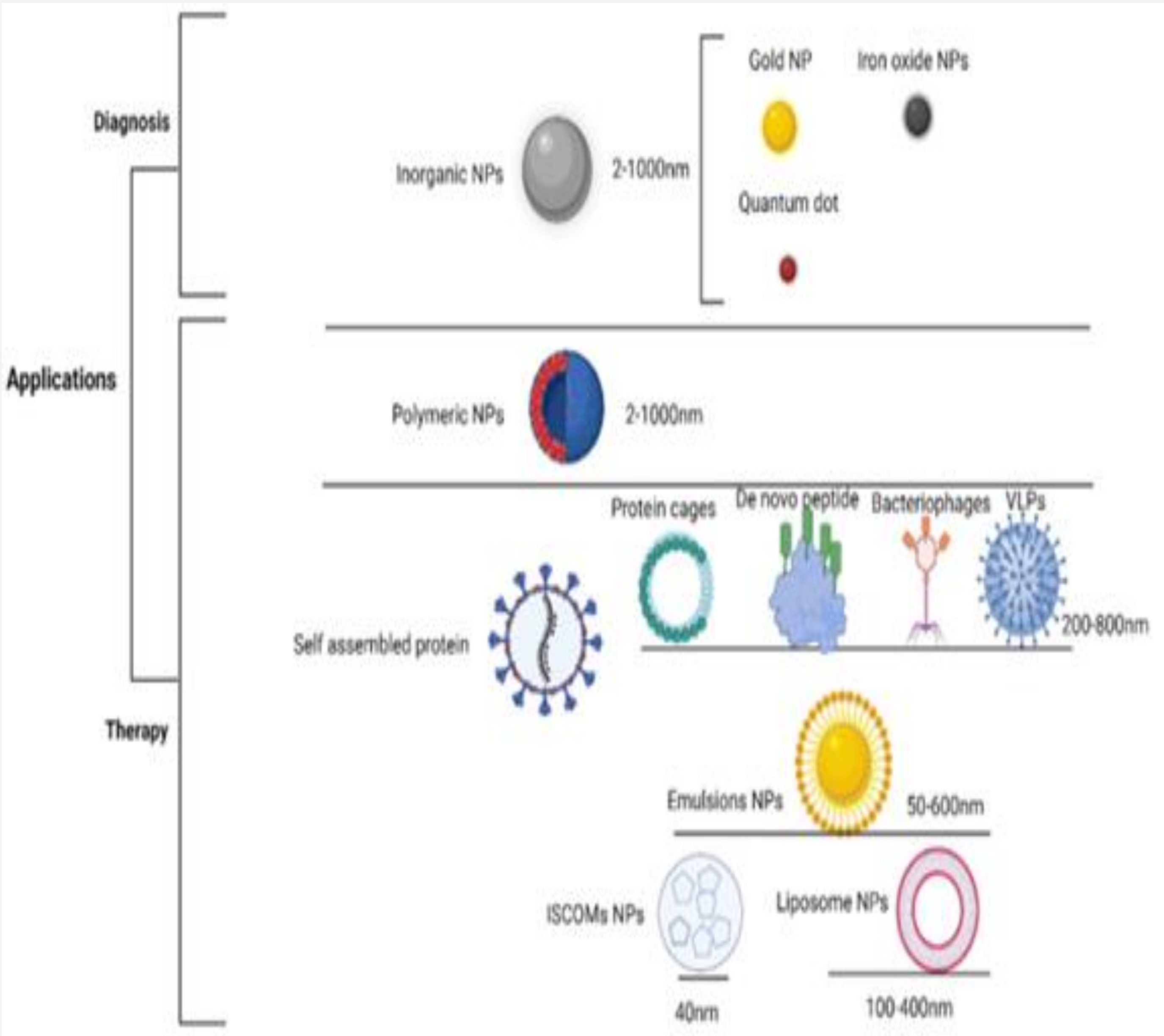

Fig 1: Summary of different types of nanoparticles (NPs) based on their size and applications.

3. Results

- Nanoparticles greatly enhanced imaging sensitivity and specificity, enabling earlier and more accurate disease detection.

- Nanoparticle-based biosensors offered rapid, precise biomarker identification, improving point-of-care diagnostics.

Nanobiosensor	Nanomaterial	Application	Reference
Antibiotic residue sensor	Au,Pt and SiO2 NPs	Sulfadiazine	Liang, et al., 2023
QDs nanobiosensor	QDs	Pathogens	Efros, et al., 2018
Artificial nasal sensor	Carbon NPs	Pathogens depending on the organic compounds released	Kim, et al., 2021
Nanorobot sensor device (NRSD)	Carbon metal nanocomposites	Diabetes control	Cavalcanti, et al., 2018
ON-Chip Disposable Salivary Glucose Sensor	CNTs, Au NPs	Diabetes control	Du, et al., 2016
Optical fiber nanobiosensor	Silver-coated nanoprobes	Cancer detection	Zheng & Li, et al., 2010

Table 1: Cases of nanobiosensors that have already been applied clinically.

3. Results

- In treatments, nanoparticle drug delivery systems provided controlled release and targeted action, reducing side effects and enhancing outcomes.

- Photothermal and photodynamic therapies with nanoparticles effectively destroyed diseased cells.

- Nanoparticle vectors for gene therapy showed promising results in preclinical studies.

Targeted drug delivery systems for anti-angiogenic therapeutic strategies.

Platform	Modification
Single-wall carbon nanotubes (SWCNTs)	Polyethylenimine (PEI)-SWCNTs conjugations linked with candesartan
PLA	APTEDB peptide functionalized
Albumin	Abituzumab (DI17E6)-coupled NPs
Multi-walled carbon nanotubes	Polyethyleneimine (PEI) or polyamidoamine dendrimer (PAMAM) functionalized SWCNTs
Graphene oxide	Bovine serum albumin-capped
Gelatine	Electrospun gelatin nanofibers

Table 2: Use of drug delivery systems.

4. Conclusions

- The convergence of nanoparticles and biomarkers promises to advance disease diagnosis and treatment by enabling early detection, targeted therapy, and personalized care.

- **Challenges:** nanoparticle stability, targeting efficiency and regulatory issues

- Future research should address these challenges and focus on translating advancements into clinical practice.

Future perspectives

- Increased retention time of nanoparticles in the body, thus enhancing their effectiveness.
- Replacement of potentially toxic elements in the formulation.
- Real-time monitoring of drug distribution in the body and patient response.
- Enhanced contrast for medical imaging.
- Rapid detection of biomarkers at lower thresholds.

5. References

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