DNA extraction methods using magnetic beads

What is magnetic separation?
Magnetic separation uses a magnetic field to separate micrometer-sized paramagnetic particles from a suspension. In molecular biology, magnetic beads provide a simple and reliable method of purifying various types of biomolecule, including genomic DNA, plasmids, mitochondrial DNA, RNA, and proteins.
• What are magnetic beads?

• Magnetic beads (or superparamagnetic particles) are versatile little tools for easy and effective isolation of biomolecules.

• Magnetic beads are made up of tiny (20 to 30 nm) particles of iron oxides, such as magnetite (Fe3O4), which give them superparamagnetic properties.

• Superparamagnetism is created by embedding small size ferromagnetic materials in non-ferromagnetic matrix. In this mixture, the magnetic domains in ferromagnetic materials are separated from each other in a way that there is no interaction between them.
Magnetic beads DNA complex
• There are many types of magnetic beads available. Different surface coatings and chemistries give each type of bead its own binding properties, which can be used for magnetic separation (isolation and purification) of nucleic acids, proteins, or other biomolecules in an easy, effective, and scalable way. This ease-of-use makes them automation friendly and well suited for a range of applications.

• **Magnetic carriers composition:** Magnetic carriers with immobilised affinity ligands and prepared from a biopolymer exhibiting affinity to the target nucleic acid are used for the isolation process. Many magnetic carriers are commercially available, such materials are magnetic particles produced from different organic synthetic polymers (Silica surface, Cellulose, Pore-free glass shell, Polyvinyl alcohol, Silanisation of iron Oxide).
• or magnetic particles based on inorganic magnetic materials such as surface-modified iron oxide. Especially suited are superparamagnetic particles, which do not interact among each other in the absence of a magnetic field. These particles will magnetise under a strong magnetic field, but retain no permanent magnetism once the field is removed. When magnetic aggregation and clumping of the particles are prevented during the reaction, easy suspension of the particles and uniform nucleic acid extraction are ensured.
• **Force on a Magnetized Particle in a Magnetic Field**

Magnetic particles used in this work for extract of DNA molecules from whole blood are designed to exhibit superparamagnetic behaviour. These particles are mixed with blood and other reagents and are exposed to a non-uniform magnetic field in order to create sufficient mixing to increase the chance of DNA-Particle bindings. Magnetic particles will be magnetised under external magnetic field and will experience net magnetic force under non-uniform magnetic field.

• **Superparamagnetic beads** are different to more common ferromagnets in that they exhibit magnetic behavior only in the presence of an **external magnetic field**. This property is dependent on the small size of the particles in the beads, and enables the beads to be separated in suspension, along with anything they are bound to. Since they don’t attract each other outside of a magnetic field, they can be used without any concern about unwanted clumping.
• **For example**, under optimized conditions, DNA selectively binds to an appropriately-coated bead surface, leaving contaminants in solution. You can then use this purified DNA directly in molecular biology applications.

• A key advantage to using magnetic beads is that you can isolate nucleic acids and other biomolecules directly from a crude sample, and from a variety of different types of sample, with minimal processing. This sets magnetic beads apart from other methods of nucleic acid isolation, which might have different protocols for different types of sample.
How does magnetic bead DNA extraction work?

Magnetic beads DNA extraction relies on using magnetic beads with a coating that can bind nucleic acids reversibly by just adjusting buffer conditions (Fig 1).

After binding DNA, an external magnetic field attracts the beads to the outer edge of the containing tube, immobilizing them. While the beads are immobilized, the bead-bound DNA is retained during the washing steps. Adding elution buffer, and removing the magnetic field then releases the DNA as a purified sample, ready for quantitation and analysis.
• Overview of magnetic bead-based DNA extraction using Sera-Mag beads.

- Magnetic particles are added to sample and bind to target molecule.
- Magnetic particles are captured and remainder of sample is washed away.
- Target molecule is released from magnetic particles for further analysis.
• **A typical protocol**, which uses magnetic beads (MBs) to isolate DNA from the whole blood, is illustrated in Figure 2. It involves the use of blood sample, beads, and five different reagents which includes Lysis Buffer Binding Buffer, Washing Buffer and Elution Buffer. In Step 1, we mix the whole blood with Lysis Buffer for cell lyses. In step 2, we add in the magnetic beads and Binding Buffer to absorb DNA. In step 3-6, we immobilize the beads and remove the suspension and contaminant. In step 7, Elution Buffer elutes the DNA from beads.
Advantages of magnetic bead-based DNA extraction

• Nucleic acids can be isolated directly from crude sample materials such as blood, tissue homogenates, cultivation media, water, etc.
• This approach removes the need for vacuum or centrifugation, which minimizes stress or shearing forces on the target molecules, requires fewer steps and reagents than other DNA extraction protocols,
• These upcoming separation techniques also serve as a basis of various automated low- to high-throughput procedures that allow to saving time and money and are amenable to automation in 24, 96, and 384-well plates.
• Centrifugation steps can be avoided and the risk of cross-contamination when using traditional methods is no longer encountered.
• Magnetic separators working in the manual and automated mode.