Indian Institute of Technology Delhi

School of Interdisciplinary Research (SIRe)

Project Proposal for Ph.D.

SIRe Project Number

2026-01-28

(will be assigned by SIRe)

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)	
Project Title	Development and validation of a magnetic immunocapture-based method for high-yield isolation of circulating fetal DNA/cells for advanced prenatal diagnostics
Project Summary (Minimum 500 and maximum 2000 characters)	Non-invasive prenatal testing (NIPT) has revolutionized prenatal care by enabling fetal genetic analysis from a maternal blood draw, avoiding the risks associated with invasive procedures like amniocentesis. Current standard NIPT relies heavily on cell-free fetal DNA (cffDNA) circulating in maternal plasma. While effective for screening common aneuploidies, cffDNA is fragmented, highly contaminated with maternal DNA background, and present in low concentrations, severely limiting its utility for higher-resolution genomic analyses. To overcome these constraints, this project focuses on intact circulating fetal cells (cFCs), such as fetal nucleated red blood cells (fnRBCs) or trophoblasts. Because these intact cells contain the complete fetal genome, isolated cleanly from the maternal background, they possess superior diagnostic potential. However, cFCs are extremely rare—often occurring at a concentration of only one cell per one million to one billion maternal blood cells—making their efficient and pure isolation one of the greatest technical challenges in prenatal medicine. This project addresses this critical bottleneck by developing and optimizing a high-efficiency magnetic immunocapture strategy for the selective isolation of rare cFCs from maternal peripheral blood. The overarching objective is to establish a standardized methodology that consistently delivers purified fetal material suitable for robust whole-genome amplification and precise downstream single-cell analysis. The methodology will employ a combination of negative selection (depleting maternal leukocytes) and positive selection using magnetic beads conjugated with antibodies targeting fetal antigens (e.g., CD71, glycophorin A, or trophoblast-specific markers). The primary focus of the experimental design will be the critical optimization of antibody density on the beads, incubation dynamics, wash buffer compositions, and magnet configurations to maximize capture efficiency (yield) while minimizing non-specific binding of maternal background (purity). Following successful capture, the purified cell population will undergo rigorous validation using quantitative PCR (qPCR) and validation techniques such as next-generation sequencing (NGS) to confirm the specific isolation of high-quality fetal material. Upon successful completion, this project will deliver an optimized, robust protocol that enables powerful, high-resolution diagnostic applications that are currently unattainable using cffDNA alone. For example, the pure fetal genome retrieved from these isolated cells will facilitate the reliable non-invasive detection of monogenic disorders (such as Cystic Fibrosis or Spinal Muscular Atrophy) by eliminating the maternal background interference that frequently obfuscates paternal or de novo mutations. Additionally, analyzing the integrity of the whole fetal genome from intact cells allows for the definitive detection of sub-chromosomal microdeletions and other Copy Number Variations (CNVs), potentially replacing invasive confirmatory testing (like amniocentesis) following a positive NIPT screen. Ultimately, this work fundamentally shifts the prenatal testing paradigm toward actionable, cell-based diagnostics, drastically improving early fetal health assessment and clinical outcomes worldwide.

Ph.D. Supervisors+ (Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)			
Role	**Name of Faculty**	**Academic Unit in IITD/Institute/University**	**Email ID (Official)**
Supervisor 1*	Prof. Ravikrishnan Elangovan	DBEB	elangovan@dbeb.iitd.ac.in
Supervisor 2	Prof.Vivekanandan Perumal	KSBS	vperumal@bioschool.iitd.ac.in

*Supervisor 1 must be from IIT, Delhi.
+All cells in this table are mandatory fields that need to be filled by faculty for consideration of proposal.
$The date of superannuation of supervisors should be at least three years from the date of registration of selected candidates.

Project requirements (Student qualifications, experience required, etc)
***The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)**

- BTech/MTech/MBA/MPP/MSc equivalent with knowledge of both quantitative and qualitative methodologies
- 60% through the career
- Candidates with experience/expertise in medical diagnosis/devices may be desirable

Source of fellowship/funding and project number
(CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)

JRF for full-time applicants.

Role of Faculty Members involved:	
Supervisor-1	Will provide expertise related to diagnostic devices and the immunomagnetic capture (has a US patent in this area)
Supervisor-2	Will provide expertise on the downstream biological applications (eg. Digital droplet PCR/NGS).

Note :-

1. **Approval from the respective DRC/CRC/ScRC of your Department/Centre/School will be required for using the "Full-time Institute Assistantship (Category-wise) (FIA)" for selecting the students in SIRe.**
2. **Declaration:- Faculty members, please ensure that you have at least 3 years of service left before superannuation along with adequate sitting space & lab facilities for the SIRe student.**
3. **PI/s are also encouraged to submit joint proposals with AIIMS, NII, JNU and institutes with which IITD has an existing MoU. If the Co-PI (Supervisor 2) is from outside IITD, kindly share his/her detailed CV.**
4. **If a research scholar is to be considered for selection under the project fellowship, then the project should have a minimum of two-year duration remaining.**
5. **A candidate applying with a valid JRF/INSPIRE/any national level fellowship should have at least two-year validity from the date of joining the Ph.D. program.**
6. **The third supervisor's name (if required) can be added only after the formation of Student Research Committee (SRC) subject to a strong recommendation of SRC and subsequent approval from the competent authority.**
7. **If Institute fellowship is being sought, then DRC approval of the parent department of Supervisor 1 is required at the time of selection.**