Stochastic Modeling, Gillespie & Noise Analysis — Hands-on

Move beyond deterministic ODEs and learn when and how to use stochastic modeling for biochemical reaction networks. This module focuses on the chemical master equation, Gillespie style simulation algorithms, noise analysis and hybrid approaches so that you can correctly capture fluctuation driven behaviour in cellular systems.

Stochastic Modeling, Gillespie & Noise Analysis

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Session Index

Session 1

Fee: Rs 8800 Apply Now

Stochastic Processes & Chemical Master Equation

Why stochastic models for biochemical systems

low copy number effects | **cell to cell variability** | **limits of deterministic ODEs**

Basics of stochastic processes in chemistry and biology

Markov jump processes | **state space and trajectories** | **propensities and hazards**

Chemical master equation (CME) intuition

probability distributions over states | link to deterministic limits | moments and fluctuation measures

Session 2

Fee: Rs 11800 Apply Now

Gillespie Algorithm & SSA Variants

Direct method (Gillespie SSA) step by step

propensity calculations | time increment sampling | reaction channel selection

Efficient variants and approximations of SSA

first reaction / next reaction methods | tau leaping basics | trade offs between accuracy and speed

Tooling for stochastic simulation experiments

COPASI / StochKit overview | Python and R implementations | SBML models with stochastic solvers

Session 3

Fee: Rs 14800 Apply Now

Noise, Variability & Hybrid Methods

Quantifying noise and variability in simulations

ensemble runs and distributions | Fano factor and coefficient of variation | noise induced switching and bursts

Intrinsic vs extrinsic noise and experimental links

single cell data interpretation | population vs lineage traces | connecting to flow / imaging readouts

Hybrid stochastic deterministic modeling strategies

partitioning fast and slow reactions | coupling SSA to ODE modules | when hybrids are appropriate

Session 4

Fee: Rs 18800 Apply Now

Mini Capstone: Stochastic Simulation of a Biochemical Circuit

Build a stochastic model for a simple gene or signaling circuit

Theory + Practical

Explore noise driven behaviours and design levers

bursting, switching or oscillations | parameter scans for noise control | comparison to deterministic model

Deliverables: code, trajectories, plots and README

simulation scripts or notebooks | summary figures and statistics | assumptions and limitations document