MIRACLE Winter Academy 2026

Data Analysis and AI-Assisted Science in Biomedical Research

Second Faculty of Medicine, Charles University, Prague

30 November – 3 December 2026

Monday 30 November 2026

Time	Session / activity
09:00–09:30	**Welcome and course introduction** Course overview, track organisation and practical information.
09:30–10:30	**Opening lecture: Acute leukaemias in children with Down syndrome — diagnosis, treatment and follow-up** *Jan-Hennig Klusmann (Frankfurt)* Diagnosis, treatment and follow-up of acute leukaemias in children with Down syndrome.
10:30–10:50	**Coffee break**
10:50–11:35	**MRD in ALL: NGS versus qPCR targeted to IG/TR rearrangements, and why biology matters** *Jan Trka / Eva Froňková* Minimal residual disease assessment in ALL: NGS and qPCR targeting IG/TR rearrangements, and the biological context of result interpretation.
11:35–12:45	**Environment setup and terminal essentials** *Practical · All participants* Installation, configuration and troubleshooting of R/RStudio, Git and the AI coding agent; terminal essentials, permissions, built-in and runtime sandboxing, and safe working environment setup.
12:45–13:45	**Lunch**
13:45–15:15	**Version control with Git** *Basics track · Practical* Fundamentals of version control: commits, diffs, reverting changes and branches; review of AI-generated changes.
13:45–15:15	**Version control with Git** *Advanced track · Practical* Collaborative workflows, branches and worktrees for parallel AI agents; automated testing before merging changes.
15:15–15:35	**Coffee break**
15:35–17:00	**R refresher** *Basics track · Practical* Puzzle-based R refresher with individual AI tutoring: vectors, loops, functions, plotting and regression, worked through step by step with hints.
15:35–17:00	**R refresher** *Advanced track · Practical* Puzzle-based R refresher with individual AI tutoring at a faster pace: vectorised code and timing, reusable functions in separate files, and extensions of the puzzle.

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Tuesday 1 December 2026

Time	Session / activity
09:00–10:15	**Computational foundations of single-cell data analysis** *Jan Stuchlý* Vector and matrix representations of single-cell data; distances, matrix factorisation (PCA, NMF) and dimensionality reduction; interpretation and limitations of reduced-dimensional representations.
10:15–10:35	**Coffee break**
10:35–12:15	**Python essentials for reading and reviewing code** *Basics track · Practical* Reading and reviewing AI-generated Python code; Conda environments, Python modules, script execution and identification of errors.
10:35–12:15	**Python tools for single-cell analysis** *Advanced track · Practical* Single-cell analysis with Scanpy and scvi-tools; data exchange between R and Python.
12:15–13:15	**Lunch**
13:15–14:45	**AI-assisted coding I** *Basics track · Practical* Instructions for AI coding agents; project instruction files (AGENTS.md, CLAUDE.md) and plugins (e.g. Superpowers); interpretation and verification of generated analysis code.
13:15–14:45	**AI-assisted coding I** *Advanced track · Practical* Structuring analysis projects and reusable code with an AI coding agent; project instruction files (AGENTS.md, CLAUDE.md) and plugins (e.g. Superpowers).
14:45–15:05	**Coffee break**
15:05–16:15	**AI-assisted coding II** *Basics track · Practical* Development of a small analysis workflow with an AI coding agent; review of code changes with Git.
15:05–16:15	**AI-assisted coding II** *Advanced track · Practical* AI-assisted improvement and extension of an existing software tool, including work with an unfamiliar programming language.
16:15–17:00	**Clonal origin and evolution in BCR::ABL1-positive leukaemias: lessons learned from MRD** *Jan Zuna* Insights from MRD monitoring into the clonal origin and evolution of BCR::ABL1-positive leukaemias.

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Wednesday 2 December 2026

Time	Session / activity
09:00–10:30	**AI-assisted science I** *Basics track · Practical* AI agents in scientific research (Claude Science, Claude Code); literature search and scientific workflows; sandboxing, permissions and critical evaluation of results.
09:00–10:30	**AI-assisted science I** *Advanced track · Practical* AI agents in scientific research (Claude Science, Claude Code); scientific workflows and tool integration; sandboxing, permissions and critical evaluation of results.
10:30–10:50	**Coffee break**
10:50–12:30	**AI-assisted science II** *Basics track · Practical* Building on Part I: agent harnesses and agent toolkits (skills, tools and workflows for scientific work); introduction to integration with external tools and data (MCP).
10:50–12:30	**AI-assisted science II** *Advanced track · Practical* Building on Part I: agent harnesses and agent toolkits for scientific work; integration with external tools and data (MCP).
12:30–13:30	**Lunch**
13:30–15:30	**Working responsibly with medical data: privacy, FAIR, AI risk and regulation** *John Jacobs* Medical data privacy and governance (GDPR, FAIR principles); AI risks and regulation in medicine (AI Act, MDR); model validation and reproducibility.
15:30–15:50	**Coffee break**
15:50–16:35	**New trends in the treatment of paediatric ALL: is the era of immunotherapy coming?** *Lucie Šrámková* Current role of immunotherapy in the treatment of paediatric ALL.
16:35–17:00	**Discussion & day wrap-up** Open discussion and summary of the day.

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Thursday 3 December 2026

Time	Session / activity
09:00–10:00	**Selected topics from statistics** *Jan Stuchlý* Probability and statistical reasoning in data analysis; worked examples in R.
10:00–10:20	**Coffee break**
10:20–12:20	**Working with imperfect data: curation, imputation and statistics in practice** *Practical · All participants* Curation of datasets in Excel and LogiqSuite/LogiqAnalytics; missing-value imputation and subsequent analysis.
12:20–13:20	**Lunch**
13:20–14:50	**Computational analysis of single-cell and flow data** *Costa Bachas* Single-cell and flow cytometry data: acquisition, preprocessing and modelling of cell populations with Gaussian mixtures.
14:50–15:10	**Coffee break**
15:10–17:00	**Single-cell practical** *Basics track · Practical* AI-assisted single-cell data analysis: preprocessing, clustering and multimodal integration; track-specific depth.
15:10–17:00	**Single-cell practical** *Advanced track · Practical* AI-assisted single-cell data analysis: preprocessing, clustering and multimodal integration; track-specific depth.

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