Rχiv-Maker: An Automated Template Engine for Streamlined Scientific Publications

Bruno M. Saraiva[1,✉], **Guillaume Jaquemet**[2,3,4,✉], **and Ricardo Henriques**[1,5,✉]

[1]Institution de Tecnologia Química e Biológica António Xavier, Universidade Nova de Lisboa, Oeiras, Portugal
[2]Faculty of Science and Engineering, Cell Biology, Åbo Akademi University, Turku, Finland
[3]InFLAMES Research Flagship Center, University of Turku, Turku, Finland
[4]Turku Bioscience Centre, University of Turku and Åbo Akademi University, Turku, Finland
[5]UCL Laboratory for Molecular Cell Biology, University College London, London, United Kingdom

Preprint servers have revolutionised scientific publishing, enabling rapid dissemination of research findings. However, researchers increasingly struggle with manuscript preparation without traditional journal production support. Rxiv-Maker addresses this challenge through a GitHub-native framework that converts markdown content to publication-ready PDFs using automated LaTeX processing. Unlike static documents, manuscripts become version-controlled, reproducible outputs that integrate seamlessly with collaborative development workflows. The framework supports programmatic figure generation from Python and R scripts, ensuring visualisations remain synchronised with underlying datasets and analysis pipelines. Key innovations include automated build environments, intelligent content protection during conversion, and Docker containerisation for reproducible execution across platforms. Rxiv-Maker democratises professional typesetting capabilities whilst maintaining computational transparency essential for open science. This manuscript exemplifies the framework's capabilities, being generated entirely through the automated pipeline to produce publication-quality output with embedded reproducibility guarantees.

article template | scientific publishing | preprints

Correspondence: ***(B. M. Saraiva) bsaraiva@itqb.unl.pt; (G. Jaquemet) guillaume.jacquemet@abo.fi; (R. Henriques) ricardo.henriques@itqb.unl.pt***

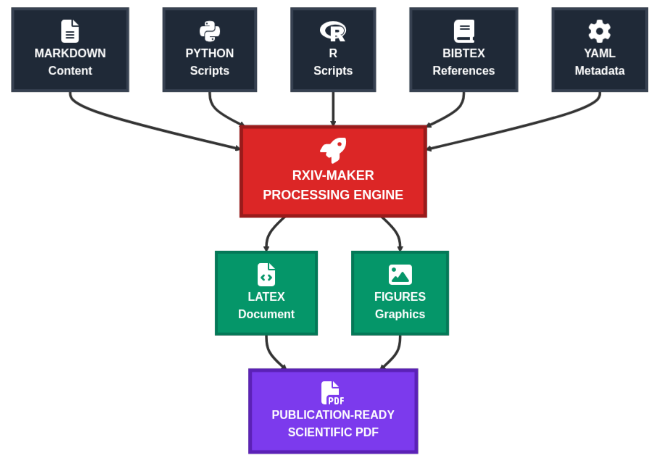

Fig. 1. The Rxiv-Maker System Diagram. The system integrates Markdown content, YAML metadata, Python and R scripts, and bibliography files through a processing engine. This engine leverages GitHub Actions, virtual environments, and LaTeX to produce a publication-ready scientific article, demonstrating a fully automated and reproducible pipeline.

Main

Scientific research increasingly depends on preprint servers such as arXiv, bioRxiv, and medRxiv for rapid dissemination (1–3). This trend, illustrated in Fig. S1 and Fig. S2, accelerates discovery whilst transferring quality control responsibilities from publishers to individual researchers (4, 5). Traditional manuscript preparation workflows remain anchored in proprietary formats that poorly integrate with version control systems, creating barriers for collaborative research (6).

This challenge proves particularly acute in computational research where algorithms, analytical methods, and processing pipelines evolve continuously. Fields ranging from computational biology to environmental modelling struggle to maintain synchronisation between evolving analysis methods and manuscript content, often resulting in publications that inadequately reflect underlying methodologies. Modern bioimage analysis exemplifies these challenges, where collaborative frameworks (7) and containerised analysis environments (8) demonstrate the critical importance of reproducible computational workflows in scientific publishing.

Rxiv-Maker addresses these challenges through a developer-centric framework optimised for reproducible preprint preparation. Rather than pursuing universal format support, the system specialises in producing publication-quality PDFs through automated LaTeX processing, enabling seamless integration with Git workflows and continuous integration practices. The framework embeds reproducibility safeguards typically handled by journal production teams, ensuring manuscripts remain buildable across different systems and time periods.

This approach transforms manuscript preparation into a transparent, auditable process that democratises access to professional publishing workflows. The system includes a Visual Studio Code extension providing intelligent syntax highlighting, automated citation management, and seamless project integration. This extension enables researchers to leverage familiar development environments whilst maintaining rigorous version control and reproducibility guarantees essential for transparent science, bridging traditional authoring workflows with contemporary best practices in computational research.

Rxiv-Maker prioritises computational reproducibility throughout the publication process, addressing fundamental challenges where data analysis and computational workflows are central (9–11). The framework enables programmatic generation of figures and tables using Python and R scripting

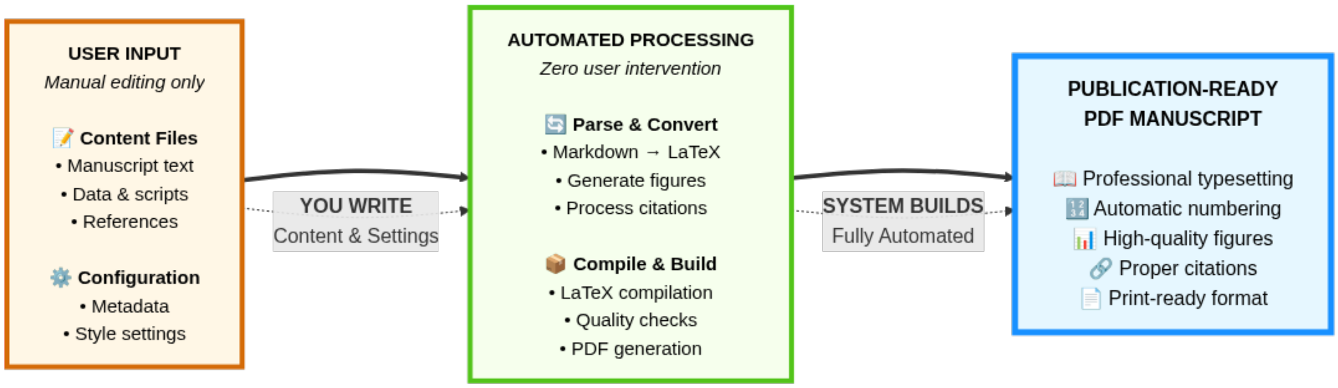

Fig. 2. Rxiv-Maker Workflow: User Input vs. Automated Processing. The framework clearly separates user responsibilities (content creation and configuration) from automated processes (parsing, conversion, compilation, and output generation). Users only need to write content and set preferences. At the same time, the system handles all technical aspects of manuscript preparation automatically, ensuring a streamlined workflow from markdown input to publication-ready PDF output.

with visualisation libraries including Matplotlib (12) and Seaborn (13).

Figures are generated directly from source datasets during compilation, establishing transparent connections between raw data, processing pipelines, and final visualisations. When datasets are updated or algorithms refined, affected figures are automatically regenerated, ensuring consistency and eliminating outdated visualisations. The system integrates Mermaid.js (14) for generating technical diagrams from text-based syntax, with the complete range of supported methods detailed in Table S1.

This approach reframes manuscripts as executable outputs of the research process rather than static documentation. Built upon the HenriquesLab bioRxiv template (15), Rxiv-Maker extends capabilities through automated processing pipelines. The architecture, detailed in Fig. 1 and Fig. 2, provides robust build automation through GitHub Actions and virtual environments, with technical details described in Supp. Note 1.

Rxiv-Maker occupies a distinctive position within the academic authoring ecosystem. All-in-one systems like Quarto offer maximum versatility with multi-language and multi-format capabilities. Collaborative editors such as Overleaf democratise LaTeX through accessible web interfaces. Computational frameworks including MyST and Jupyter Book prioritise interactive, web-first outputs. Modern typesetting engines like Typst provide cleaner syntax and faster compilation. Rxiv-Maker specialises in developer-centric automation for reproducible PDF preprint generation, particularly suited to computational workflows where dynamic figure generation and algorithmic documentation are essential. This focused approach enables deeper specialisation for manuscripts involving evolving datasets and processing pipelines. A comprehensive comparison is provided in Table S2.

Rxiv-Maker delivers an efficient workflow for producing publication-quality manuscripts that embody reproducible research principles. The system outputs professionally typeset PDF documents—exemplified by this article, generated entirely through the automated pipeline—demonstrating seamless integration of computational content with academic formatting. Markdown source files undergo automated conversion into structured LaTeX documents, compiled to produce PDFs with rigorous typography, proper pagination, and high-resolution figures maintaining publication standards.

The deployment strategy addresses computational reproducibility through Docker containerisation, encapsulating the complete environment—LaTeX distributions, Python libraries, R packages, and system dependencies—within immutable container images. GitHub Actions workflows leverage pre-compiled Docker images for standardised compilation processes, reducing build times from 8-10 minutes to approximately 2 minutes. The Docker engine mode (`RXIV_ENGINE=DOCKER`) enables researchers to generate PDFs with only Docker as a prerequisite, valuable for collaborative research across platforms or institutional settings with software restrictions (16).

PDF artefacts are automatically archived and made available, creating computational provenance from source files to final output. The system supports deployment in Google Colab notebooks for users requiring immediate feedback, maintaining reproducibility guarantees whilst offering real-time compilation. A Docker-accelerated version leverages udocker (17) for containerized execution, reducing setup time from approximately 20 minutes to 4 minutes whilst providing pre-configured environments with all dependencies. This approach eliminates manual dependency installation and ensures consistent execution across Google Colab sessions. Available deployment strategies are compared in Table S3.

Programmatic figure generation supports interactive environments including Jupyter notebooks (18). Python and R scripts placed within designated directories are automatically executed during compilation, loading data, performing analyses, and generating visualisations seamlessly included in the final PDF. Mermaid.js diagrams embedded within markdown are rendered into SVG images and incorporated into the document. This integration demonstrates closed-loop reproducibility, where manuscripts serve as verifiable, self-contained records of research findings.

The Visual Studio Code extension provides intelligent editing features including real-time syntax highlighting, autocompletion for bibliographic citations from BibTeX files, and seamless cross-reference management. The extension reduces cognitive load and minimises syntax errors whilst maintaining consistent formatting.

Rxiv-Maker integrates accessible plain-text authoring with automated build environments, democratising solutions to consistency and reproducibility challenges in scientific publishing. This approach embraces literate programming principles (19), creating living documents that blend narrative communication with executable workflows whilst abstracting typesetting complexity. Integration with Git provides transparent attribution, conflict-free merging, and auditable histories of manuscript development (20, 21), fostering collaborative practices essential for open science.

The rise of preprints has shifted quality control and typesetting responsibilities from journals to individual authors, creating both opportunities and challenges for scientific communication. Rxiv-Maker responds by providing automated safeguards that enable researchers to produce publication-quality work without extensive typesetting expertise, democratising access to sophisticated publishing capabilities through GitHub-native infrastructure.

The focus on PDF output via LaTeX optimises preprint workflows through specialisation for scientific publishing requirements. Future development will explore extending format support through integration with universal converters such as Pandoc (22), preserving typographic control and reproducibility standards. The Visual Studio Code extension addresses adoption barriers by providing familiar development environments that bridge text editing with version control workflows. Future development will prioritise deeper integration with computational environments and quality assessment tools, building upon established collaborative frameworks (7) and containerised approaches that enhance reproducibility (8). These developments will enhance the platform's role in collaborative manuscript preparation across diverse computational research domains.

The system supports scientific publishing through organised project structure separating content, configuration, and computational elements. All manuscript content, metadata, and bibliographic references are version-controlled, ensuring transparency.

The markdown-to-LaTeX conversion pipeline handles complex academic syntax including figures, tables, citations, and mathematical expressions whilst preserving semantic meaning and typographical quality. The system employs a multi-pass approach protecting literal content during transformation, ensuring intricate scientific expressions are rendered accurately. The framework supports subscript and superscript notation essential for chemical formulas, allowing expressions such as H_2O, CO_2, Ca^{2+}, SO_4^{2-}, and $E = mc^2$, as well as temperature notation like 25°C.

The system's mathematical typesetting capabilities extend to numbered equations, which are essential for scientific manuscripts. For instance, the fundamental equation relating mass and energy can be expressed as:

$$E = mc^2 \tag{1}$$

The framework also supports more complex mathematical formulations, such as the standard deviation calculation commonly used in data analysis:

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2} \tag{2}$$

Additionally, the system handles chemical equilibrium expressions, which are crucial in biochemical and chemical research:

$$K_{eq} = \frac{[\mathrm{Products}]}{[\mathrm{Reactants}]} = \frac{[\mathrm{Ca}^{2+][\mathrm{SO}_4 2-]}}{[\mathrm{CaSO}_4]} \tag{3}$$

These numbered equations (Eq. (1), Eq. (2), and Eq. (3)) demonstrate the framework's capability to handle diverse mathematical notation whilst maintaining proper cross-referencing throughout the manuscript. This functionality ensures that complex scientific concepts can be presented with the precision and clarity required for academic publication.

Rxiv-Maker is optimised for reproducible PDF preprint generation within the scientific authoring ecosystem. While platforms such as Overleaf and Quarto offer multi-format capabilities, Rxiv-Maker provides focused, developer-centric workflows integrating with version control and automated build environments. This specialisation enables optimisation for preprint preparation requirements, ensuring manuscripts are professionally typeset and computationally reproducible.

The framework provides practical training in version control, automated workflows, and computational reproducibility—skills fundamental to modern scientific practice. Researchers naturally acquire technical competencies including Git proficiency, markdown authoring, continuous integration, and containerised environments. The system is designed to be accessible without extensive programming backgrounds, featuring comprehensive documentation and intuitive workflows that reduce barriers whilst fostering skill development.

The technical architecture addresses computational constraints of cloud-based build systems through intelligent caching mechanisms and selective content regeneration, enabling efficient resource use. The framework supports high-resolution graphics and advanced figure layouts whilst maintaining optimal document organisation and cross-referencing functionality.

Rxiv-Maker represents a paradigm shift in scientific publishing, transforming manuscripts from static documents into dynamic, executable research artefacts. By democratising access to professional publishing technologies whilst embedding computational reproducibility guarantees, the framework empowers researchers to produce transparent, verifiable publications that serve both immediate dissemination and long-term preservation.

This approach addresses fundamental challenges in modern computational research, where the gap between sophisticated analytical methods and traditional publishing workflows continues to widen. Rxiv-Maker bridges this divide by treating manuscripts as version-controlled software projects, enabling the same collaborative development practices that have revolutionised software engineering to enhance scientific communication.

The framework's impact extends beyond technical capabilities to foster a culture of computational literacy and transparent science. As preprint servers continue to reshape academic publishing, tools like Rxiv-Maker become essential infrastructure for maintaining quality and reproducibility in researcher-led publication processes. The framework serves as both a practical solution for immediate publishing needs and a foundation for advancing open science principles across diverse research domains.

ABOUT THIS MANUSCRIPT

DATA AVAILABILITY

arXiv monthly submission data used in this article is available at https://arxiv.org/stats/monthly_submissions. Preprint submissions data across different hosting platforms is available at https://github.com/esperr/pubmed-by-year. The source code and data for the figures in this article are available at https://github.com/henriques/rxiv-maker.

CODE AVAILABILITY

The Rxiv-Maker computational framework is available at https://github.com/henriques/rxiv-maker. The framework includes comprehensive documentation, example manuscripts, and automated testing suites to ensure reliability across different deployment environments. Additionally, the Visual Studio Code extension for Rxiv-Maker is available at https://github.com/HenriquesLab/vscode-rxiv-maker, providing researchers with an integrated development environment that includes syntax highlighting, intelligent autocompletion for citations and cross-references, schema validation for configuration files, and seamless integration with the main framework's build processes. All source code is under an MIT License, enabling free use, modification, and distribution for both academic and commercial applications.

AUTHOR CONTRIBUTIONS

Both Bruno M. Saraiva, Guillaume Jacquemet, and Ricardo Henriques conceived the project and designed the framework. All authors contributed to writing and reviewing the manuscript.

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EXTENDED AUTHOR INFORMATION

- **Bruno M. Saraiva:**
  0000-0002-9151-5477; Bruno_MSaraiva; bruno-saraiva
- **Guillaume Jaquemet:**
  0000-0002-9286-920X; guijacquemet; guijacquemet.bsky.social
- **Ricardo Henriques:**
  0000-0002-2043-5234; HenriquesLab; henriqueslab.bsky.social; ricardo-henriques

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Methods

This section provides technical description of the Rxiv-Maker framework, demonstrating the system's capacity to generate structured documentation from source code and plain text. System architecture is detailed in Fig. S3.

Processing Pipeline. Rxiv-Maker employs a sophisticated multi-stage processing pipeline orchestrated through a central `Makefile` that converts manuscript source files into publication-ready PDFs. The pipeline ensures computational reproducibility through five controlled stages:

1. **Environment Setup**: Automated dependency resolution with containerised environments using Docker or local virtual environments with pinned package versions

2. **Content Generation**: Conditional execution of Python/R scripts and Mermaid diagram compilation based on modification timestamps

3. **Markdown Processing**: Multi-pass conversion with intelligent content protection preserving mathematical expressions, code blocks, and LaTeX commands

4. **Asset Aggregation**: Systematic collection and validation of figures, tables, and bibliographic references with integrity checking

5. **LaTeX Compilation**: Optimised `pdflatex` sequences with automatic cross-reference and citation resolution

For users without local LaTeX installations, the framework provides identical build capabilities through cloud-based GitHub Actions, democratising access to professional publishing workflows whilst maintaining reproducibility guarantees.

Markdown-to-LaTeX Conversion. Manuscript conversion is handled by a Python processing engine managing complex academic syntax requirements through "rxiv-markdown". This multi-pass conversion system employs content protection strategies preserving computational elements such as code blocks and mathematical notation, converting specialised academic elements including dynamic citations (`@smith2023`), programmatic figures, statistical tables, and supplementary notes before applying standard markdown formatting. This approach ensures complex academic syntax is handled with precision across research domains. Supported syntax is detailed in Table S4. The system supports notation essential for scientific disciplines: subscript and superscript syntax for chemical formulas such as H_2O and CO_2, mathematical expressions including Einstein's mass-energy equivalence (Eq. (1)), chemical notation such as Ca^{2+} and SO_4^{2-} (Eq. (3)), temperature specifications like 25°C, and statistical calculations including standard deviation (Eq. (2)). The framework supports complex mathematical expressions typical of computational workflows:

$$\frac{\partial}{\partial t}\mathbf{u}+(\mathbf{u}\cdot\nabla)\mathbf{u}=-\frac{1}{\rho}\nabla p+\nu\nabla^2\mathbf{u} \quad (4)$$

This approach provides accessible alternatives for common formulas whilst ensuring complex equations like the Navier-Stokes equation (Eq. (4)) are rendered with professional quality. Mathematical formula support is detailed in Supp. Note 2.

Programmatic Content and Environments. The framework provides programmatic content generation treating figures, statistical analyses, and algorithmic diagrams as reproducible computational outputs linked to source data and processing pipelines. The build pipeline executes scripting environments including Python, R, and Mermaid, employing intelligent caching mechanisms to avoid redundant computation whilst maintaining traceability between datasets, algorithms, and visualisations (Supp. Note 1). Rxiv-Maker implements multi-layered environment management addressing complex dependency requirements. Dependencies are rigorously pinned, isolated virtual environments support development workflows, and containerised environments ensure consistent execution across computing platforms. Cloud-based GitHub Actions provide controlled, auditable build environments guaranteeing identical computational outcomes across systems.

Deployment Architecture and Platform Considerations. The framework provides flexible deployment strategies for diverse research environments. Local installation offers optimal performance and universal architecture compatibility, supporting AMD64 and ARM64 systems with direct access to native resources required for diagram generation. This approach enables faster iteration cycles and comprehensive debugging capabilities.

Containerised execution through Docker Engine Mode eliminates local dependency management by providing pre-configured environments containing LaTeX distributions, Python libraries, R packages, and Node.js tooling. Due to Google Chrome limitations for ARM64 Linux distributions, Docker deployment uses AMD64 base images running via Rosetta emulation on Apple Silicon systems. For optimal performance on ARM64 systems, local installation provides full capabilities without emulation overhead.

Cloud-based deployment through GitHub Actions provides architecture-agnostic automated builds for continuous integration workflows. The modular architecture enables researchers to select deployment strategies appropriate to technical constraints whilst maintaining reproducibility guarantees.

Visual Studio Code Extension. Rxiv-Maker includes a Visual Studio Code extension providing an integrated development environment for collaborative manuscript preparation. The extension leverages the Language Server Protocol delivering real-time syntax highlighting for academic markdown syntax, intelligent autocompletion for bibliographic citations from BibTeX files, and context-aware suggestions for cross-references to figures, tables, equations, and supplementary materials. The extension integrates with the main framework through file system monitoring and automated workspace detection, recognising rxiv-maker project structures and providing appropriate editing features. Schema validation for YAML configuration files ensures project metadata adheres to reproducibility specifications, whilst integrated terminal access enables direct execution of framework commands. This provides researchers with accessible, feature-rich editing experience maintaining reproducibility guarantees whilst reducing technical barriers.

Quality Assurance. Framework reliability is ensured through multi-level validation protocols. Unit tests validate individual components, integration tests verify end-to-end pipelines, and platform tests validate deployment environment behaviour. Pre-commit pipelines enforce code formatting, linting, and type checking, ensuring code quality.

Supplementary Information

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Format	Input Extension	Processing Method	Output Formats	Quality	Use Case
Mermaid Diagrams	`.mmd`	Mermaid CLI	SVG, PNG, PDF	Vector/Raster	Flowcharts, architectures
Python and R Figures	`.py`, `.R`	Script execution	PNG, PDF, SVG	Publication	Data visualisation
Static Images	`.png`, `.jpg`, `.svg`	Direct inclusion	Same format	Original	Photographs, logos
LaTeX Graphics	`.tex`, `.tikz`	LaTeX compilation	PDF	Vector	Mathematical diagrams
Data Files	`.csv`, `.json`, `.xlsx`	Python and R processing	Via scripts	Computed	Raw data integration

Sup. Table S1. Supported Figure Generation Methods. Comprehensive overview of the framework's figure processing capabilities, demonstrating support for both static and dynamic content generation with emphasis on reproducible computational graphics.

Tool	Type	Markdown	Primary Use Case	Key Strengths	Open Source
Rxiv-Maker	Pipeline	Excellent	Preprint servers	GitHub Actions integration, automated workflows	Yes
Overleaf (23)	Web Editor	Limited	Academic publishing	Real-time collaboration, rich templates	Freemium
Quarto (24)	Publisher	Native	Multi-format publishing	Polyglot support, multiple outputs	Yes
Pandoc (22)	Converter	Excellent	Format conversion	Universal format support, extensible	Yes
Typst (25)	Typesetter	Good	Modern typesetting	Fast compilation, modern syntax	Yes
Bookdown (26)	Publisher	R Markdown	Academic books	Cross-references, multiple formats	Yes
Direct LaTeX	Typesetter	Limited	Traditional publishing	Ultimate control, established workflows	Yes

Sup. Table S2. Comprehensive Comparison of Manuscript Preparation Tools. This comparison provides an exhaustive overview of available tools for scientific manuscript preparation, positioning each within the broader ecosystem of academic publishing workflows. Rxiv-Maker is designed as a specialised solution optimising for preprint server submissions, complementing rather than replacing established tools like Overleaf for general LaTeX collaboration or Quarto for multi-format publishing. The comparison highlights that different tools excel in distinct contexts: Overleaf dominates collaborative LaTeX editing, Quarto excels at multi-format computational publishing, and Rxiv-Maker streamlines the specific workflow of preparing reproducible preprints for submission to arXiv, bioRxiv, and medRxiv.

Deployment Method	Environment	Dependencies	Collaboration	Ease of Use	Reproducibility
GitHub Actions	Cloud CI/CD	None (cloud)	Automatic	Very High	Perfect
Google Colab	Web browser	None (cloud)	Shared notebooks	Very High	High
Local Python	Local machine	Python + LaTeX	Git-based	Medium	Good
Manual LaTeX	Local machine	Full LaTeX suite	Git-based	Low	Variable

Sup. Table S3. Rxiv-Maker Deployment Strategies. Comparison of available compilation methods, highlighting the flexibility of the framework in accommodating different user preferences and technical environments whilst maintaining consistent output quality.

Markdown Element	LaTeX Equivalent	Description
Basic Text Formatting		
`**bold text**`	`\textbf{bold text}`	Bold formatting for emphasis
`*italic text*`	`\textit{italic text}`	Italic formatting for emphasis
`~subscript~`	`\textsubscript{subscript}`	Subscript formatting (H~2~O, CO~2~)
`^superscript^`	`\textsuperscript{superscript}`	Superscript formatting (E=mc^2^, x^n^)
Document Structure		
`# Header 1`	`\section{Header 1}`	Top-level section heading
`## Header 2`	`\subsection{Header 2}`	Second-level section heading
`### Header 3`	`\subsubsection{Header 3}`	Third-level section heading
Lists		
`- list item`	`\begin{itemize}\item...\end{itemize}`	Unordered list
`1. list item`	`\begin{enumerate}\item...\end{enumerate}`	Ordered list
Links and URLs		
`[link text](url)`	`\href{url}{link text}`	Hyperlink with custom text
`https://example.com`	`\url{https://example.com}`	Bare URL
Citations		
`@citation`	`\cite{citation}`	Single citation reference
`[@cite1;@cite2]`	`\cite{cite1,cite2}`	Multiple citation references
Cross-References		
`@fig:label`	`\ref{fig:label}`	Figure cross-reference
`@sfig:label`	`\ref{sfig:label}`	Supplementary figure cross-reference
`@table:label`	`\ref{table:label}`	Table cross-reference
`@stable:label`	`\ref{stable:label}`	Supplementary table cross-reference
`@eq:label`	`\eqref{eq:label}`	Equation cross-reference
`@snote:label`	`\sidenote{label}`	Supplement note cross-reference
Tables and Figures		
Markdown table	`\begin{table}...\end{table}`	Table with automatic formatting
Image with caption	`\begin{figure}...\end{figure}`	Figure with separate caption
Document Control		
`<!- comment ->`	`% comment`	Comments (converted to LaTeX style)
`<newpage>`	`\newpage`	Manual page break control
`<clearpage>`	`\clearpage`	Page break with float clearing

Sup. Table S4. Rxiv-Maker Markdown Syntax Overview. Comprehensive mapping of markdown elements to their LaTeX equivalents, demonstrating the automated translation system that enables researchers to write in familiar markdown syntax whilst producing professional LaTeX output.

Supp. Note 1: Programmatic Figure Generation and Computational Reproducibility. Rxiv-Maker's figure generation capabilities demonstrate automated processing pipelines maintaining transparent connections between source data and final visualisations whilst ensuring computational reproducibility. The system supports two primary methodologies: Mermaid diagram processing and Python/R-based data visualisation, each addressing distinct requirements within scientific publishing workflows.

Mermaid diagram processing leverages the Mermaid CLI to convert text-based specifications into publication-ready graphics. This approach enables version-controlled diagram creation where complex flowcharts, system architectures, and conceptual models are specified using intuitive syntax and automatically rendered into multiple output formats. The system generates SVG, PNG, and PDF variants accommodating different compilation requirements whilst maintaining vector quality. This automation eliminates manual effort for diagram creation and updates, ensuring modifications are immediately reflected in the final document.

Script-based figure generation represents computational reproducibility where analytical scripts execute during compilation to generate figures directly from source data. This integration ensures visualisations remain synchronised with underlying datasets and analytical methods, eliminating outdated or inconsistent graphics. The system executes image generation scripts within the compilation environment, automatically detecting generated files and incorporating them into document structure. This approach transforms figures from static illustrations into dynamic, reproducible computational artefacts enhancing scientific rigour.

Supp. Note 2: Mathematical Formula Support and LaTeX Integration. Rxiv-Maker integrates mathematical notation by translating markdown-style expressions into publication-ready LaTeX mathematics. This enables researchers to author complex mathematical content using familiar syntax whilst benefiting from LaTeX's superior typesetting capabilities.

Inline mathematical expressions use dollar sign delimiters (`$...$`), enabling formulas such as $E = mc^2$ or $\alpha = \frac{\beta}{\gamma}$ to be embedded within text. The conversion system preserves expressions during markdown-to-LaTeX transformation, ensuring

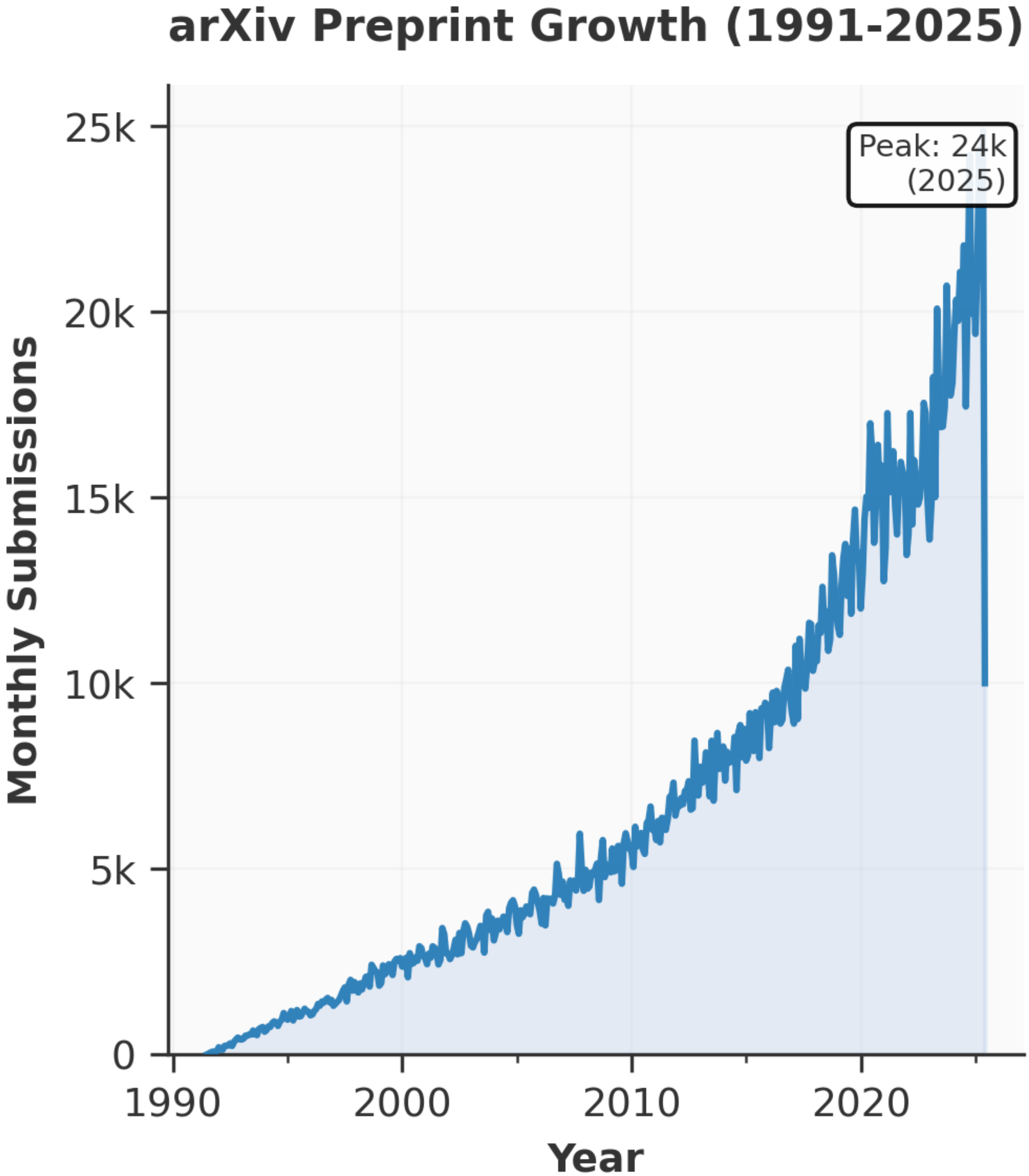
mathematical notation maintains proper formatting and spacing.
Display equations utilise double dollar delimiters (`$$...$$`) for prominent mathematical expressions requiring centred presentation. Complex equations such as the Schrödinger equation:

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t) = \hat{H}\Psi(\mathbf{r},t)$$

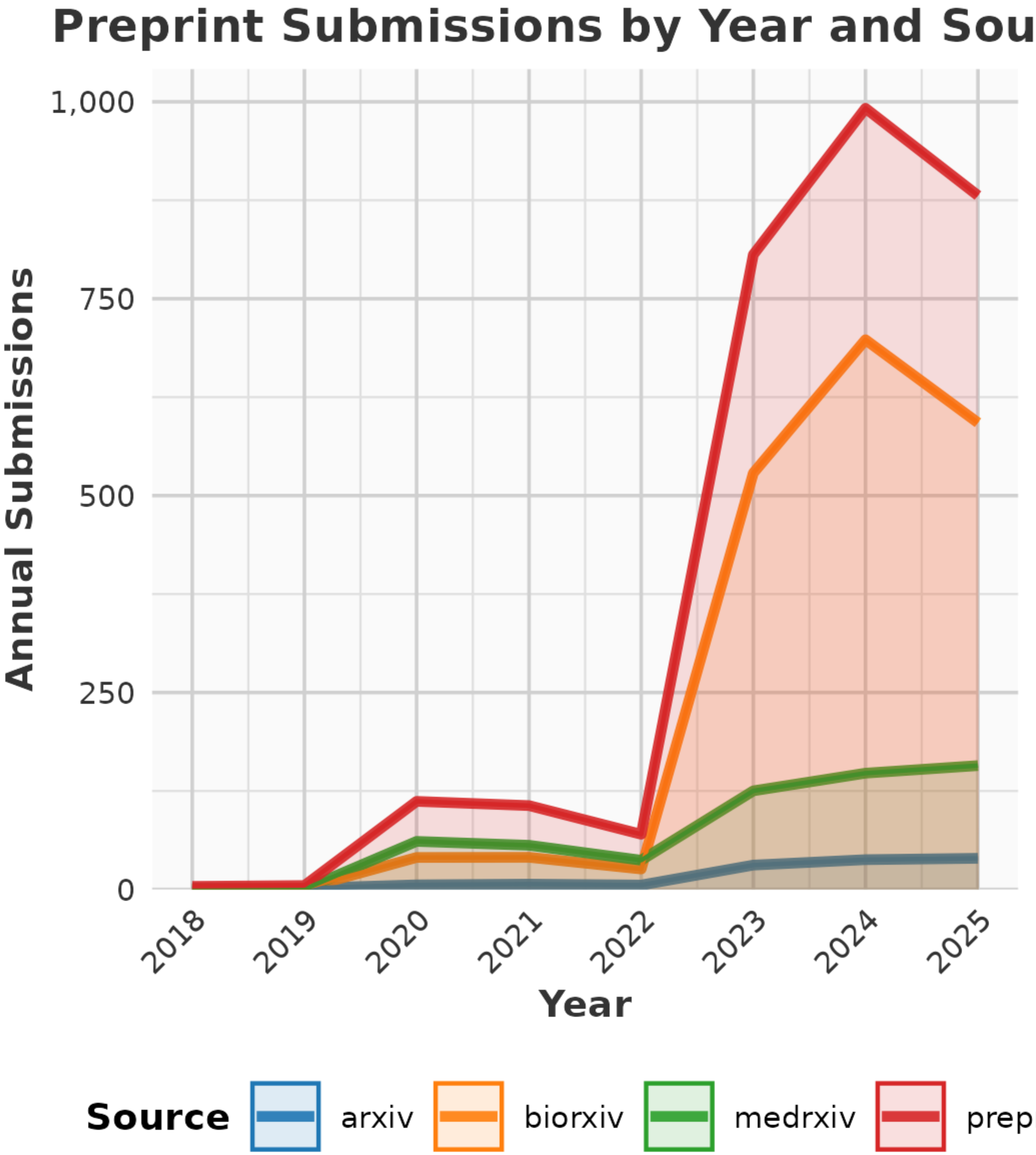
or the Navier-Stokes equations:

$$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v}\cdot\nabla\mathbf{v}\right) = -\nabla p + \mu\nabla^2\mathbf{v} + \mathbf{f}$$

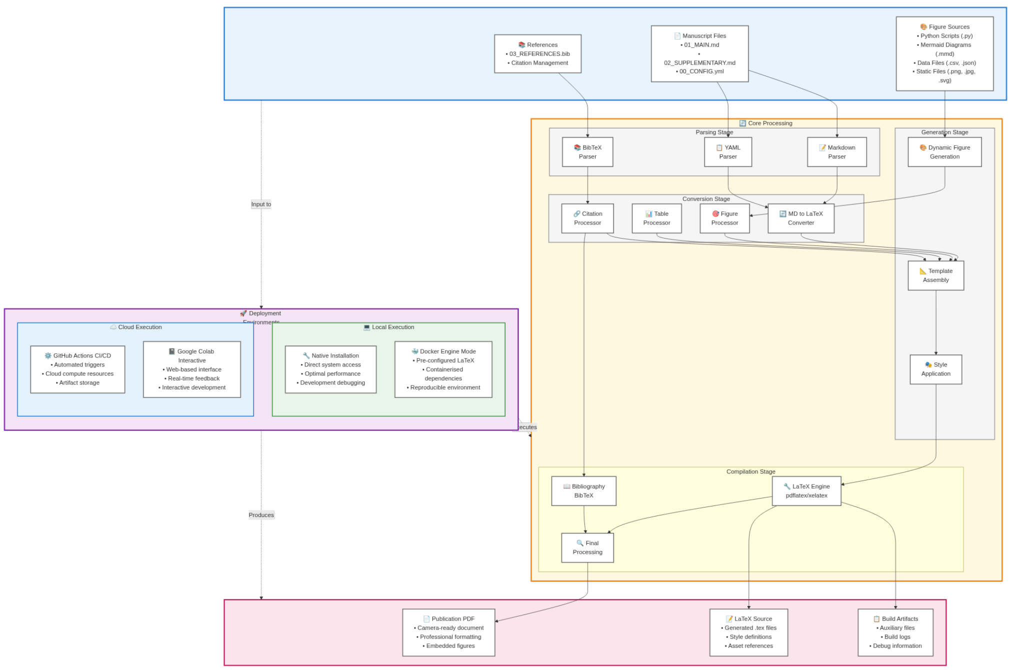
demonstrate the framework's capability to handle sophisticated mathematical typography, including Greek letters, partial derivatives, vector notation, and complex fraction structures.
The system supports LaTeX's mathematical environments by directly including LaTeX code blocks. This hybrid approach enables simple markdown syntax for straightforward expressions whilst retaining access to LaTeX's full capabilities for complex multi-line derivations.
Mathematical expressions within figure captions, table entries, and cross-references are automatically processed, ensuring consistent typography throughout documents. The framework's content protection system preserves mathematical expressions during multi-stage conversion, preventing unwanted modifications.
Statistical notation commonly required in manuscripts is supported, including confidence intervals $\mu \pm \sigma$, probability distributions $P(X \leq x)$, and significance levels $p < 0.05$. Complex expressions involving summations $\sum_{i=1}^{n} x_i$, integrals $\int_{-\infty}^{\infty} f(x)dx$, and matrix operations $\mathbf{A}^{-1}\mathbf{b} = \mathbf{x}$ are rendered with appropriate spacing.



Sup. Fig. S1. The growth of preprint submissions on the arXiv server from 1991 to 2025. The data, sourced from arXiv's public statistics, is plotted using a Python script integrated into our Rxiv-Maker pipeline. This demonstrates the system's capacity for reproducible, data-driven figure generation directly within the publication workflow.



Sup. Fig. S2. Preprint Submission Trends Across Multiple Servers (2018-2025). The figure displays the annual number of preprint submissions to major repositories, including arXiv, bioRxiv, and medRxiv. Data was collected from publicly available sources (27) and visualised using a reproducible R script within the Rxiv-Maker pipeline. This approach ensures that the figure remains synchronised with the latest available data and supports transparent, data-driven scientific reporting.



Sup. Fig. S3. Detailed System Architecture and Processing Layers. Comprehensive technical diagram showing the complete Rxiv-Maker architecture, including input layer organisation, processing engine components (parsers, converters, generators), compilation infrastructure, output generation, and deployment methodology integration with Docker containerisation support. This figure illustrates the modular design that enables independent development and testing of system components across both local and containerised environments.