

Cross-language Data Grammar for Single-cell Research Feature Engineering

Dave Bunten¹,
Faisal Alquaddoomi¹,
Gregory P. Way¹

¹ Department of Biomedical Informatics, University of Colorado Anschutz

Introduction

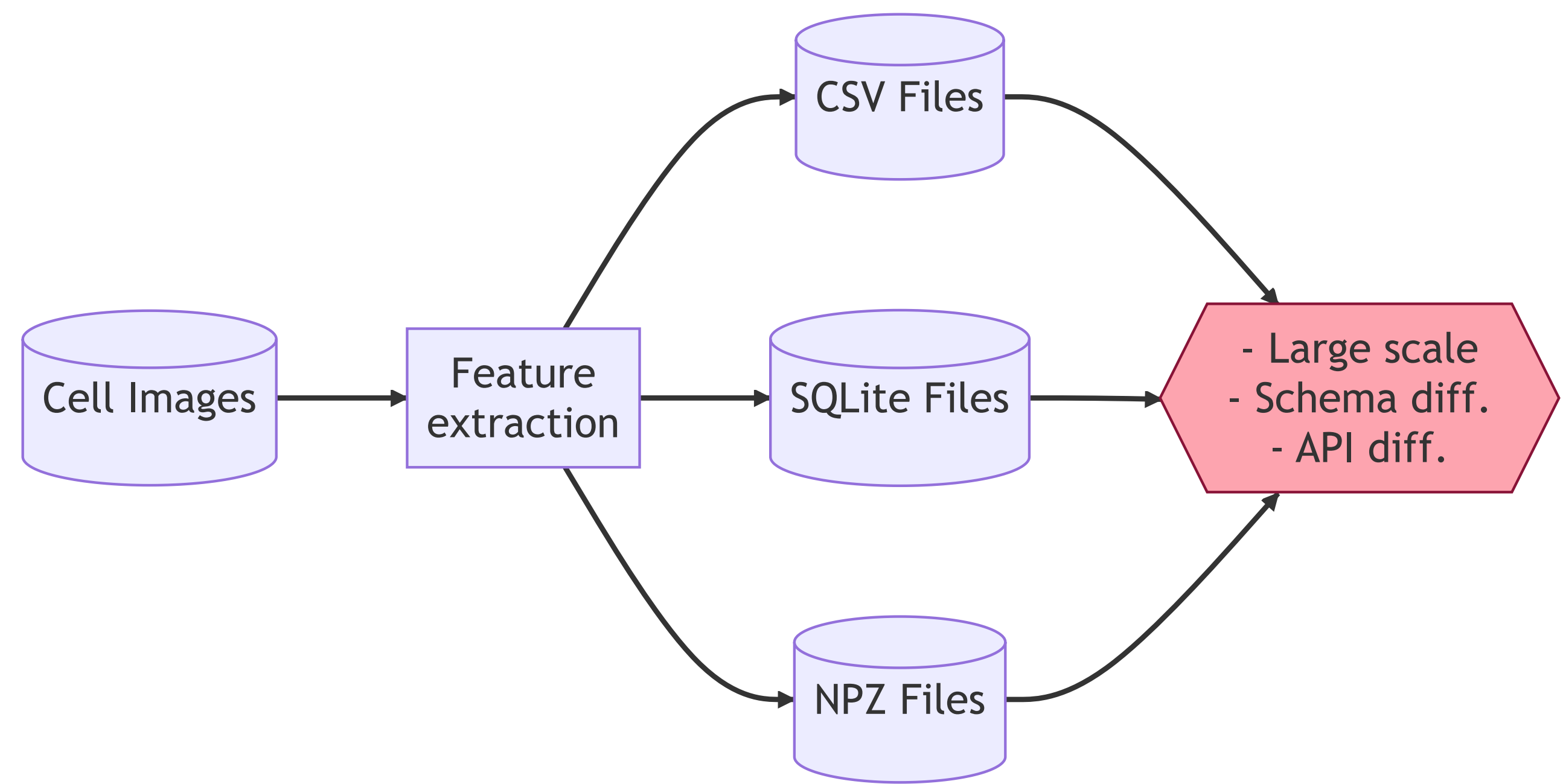


Figure 1. A diagram showing many different feature data and common challenges.

Research in the [Way Lab](#) involves intensive data engineering over high-dimensional single-cell morphology data from large-scale microscopy drug screening applications. Software development surrounding this work often entails scalability (larger than memory data handling) and understandability (syntax complexity and software sustainability) challenges.

Solution design

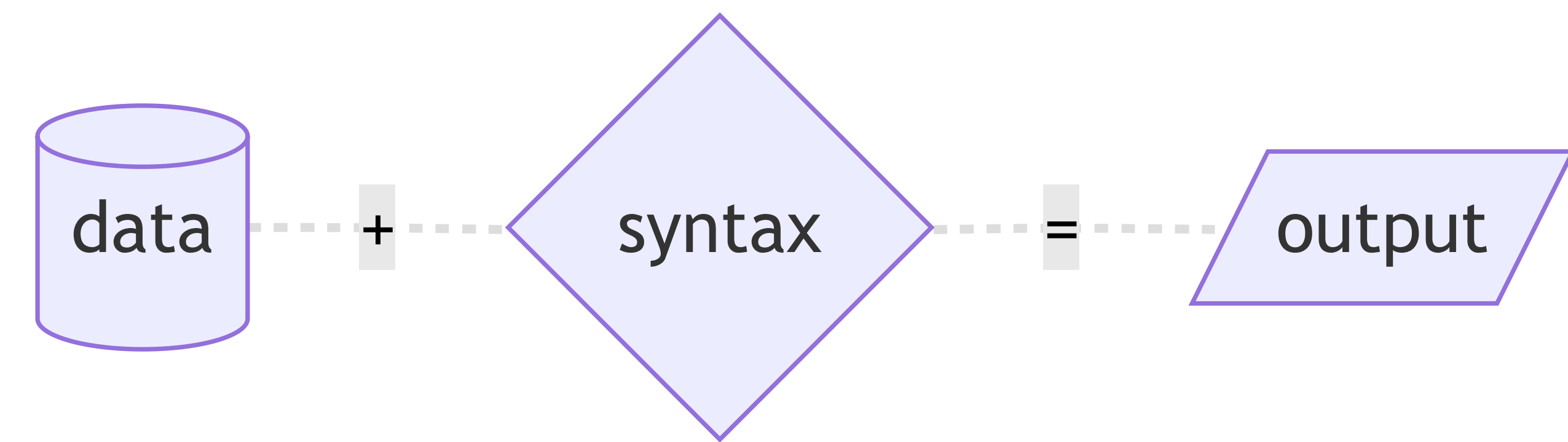
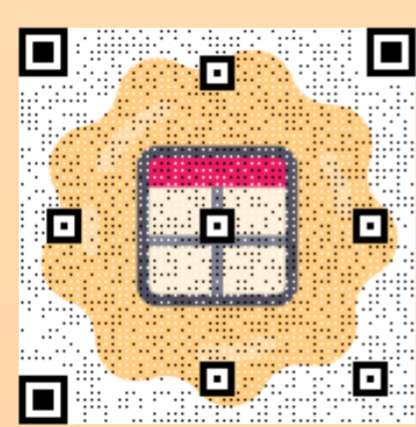
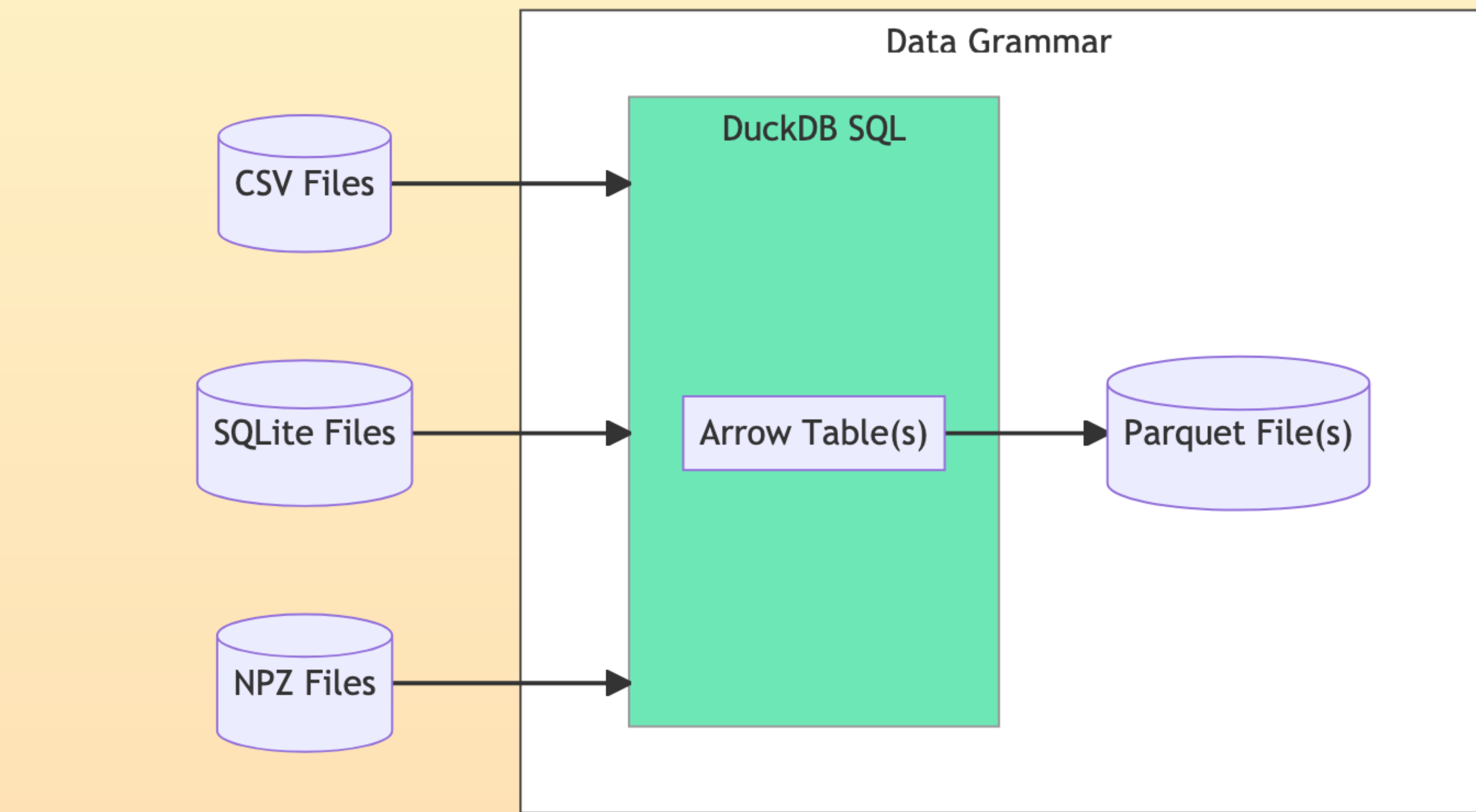


Figure 2. A diagram illustrating data grammar as an abstract linguistic algorithm.

To address these challenges we have developed a python package called [CytoTable](#) which implements “cross-language data grammar” capabilities (vocabulary + syntax = output) orchestrated with [Parsl](#) workflows. Our vision is for CytoTable to increase consistency and reliability of data and enable more scientists to quickly access single-cell insights from microscopy images.

CytoTable implements data grammar through Apache Arrow, DuckDB SQL, Apache Parquet for increased research velocity, cross-language integration, and understandability.



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Data: Apache Arrow

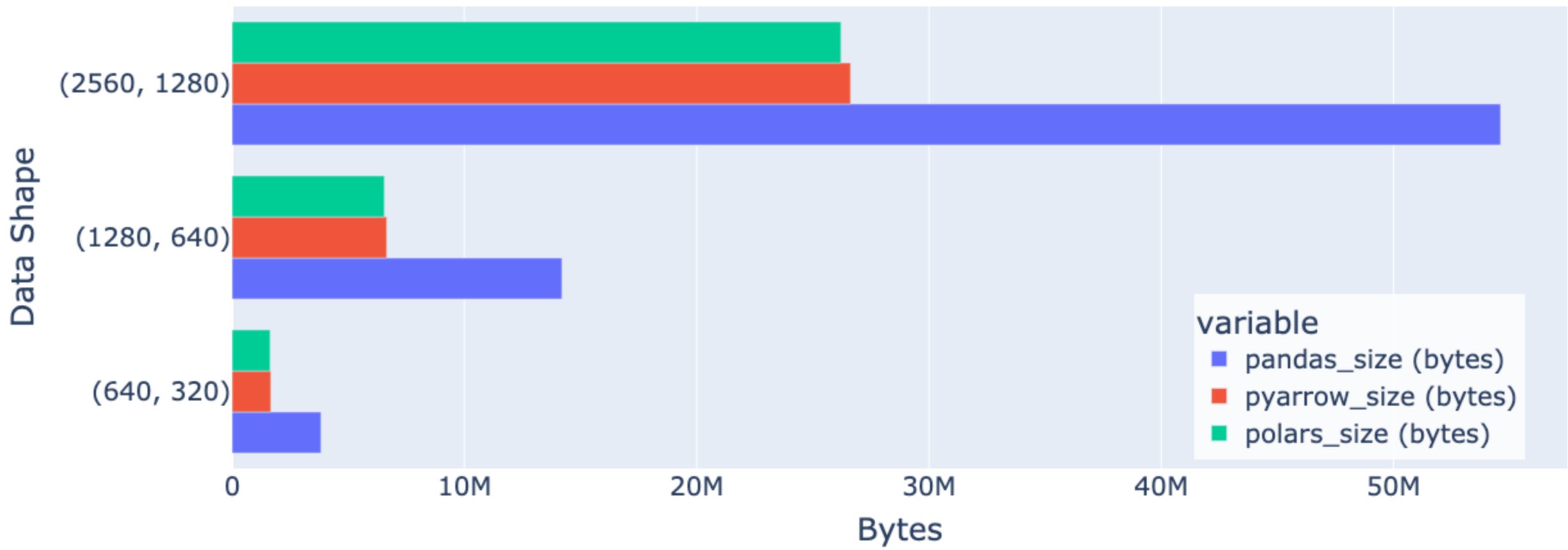


Figure 3. Chart showing relative memory size for data using various Python libraries.

[Apache Arrow](#) represents a new frontier for data implementation flexibility, enabling a unified, multi-language, zero-copy format for in-memory analysis. Arrow is like a high-performance Pandas dataframe which may be used across languages with fewer scalability challenges.

Syntax: DuckDB SQL

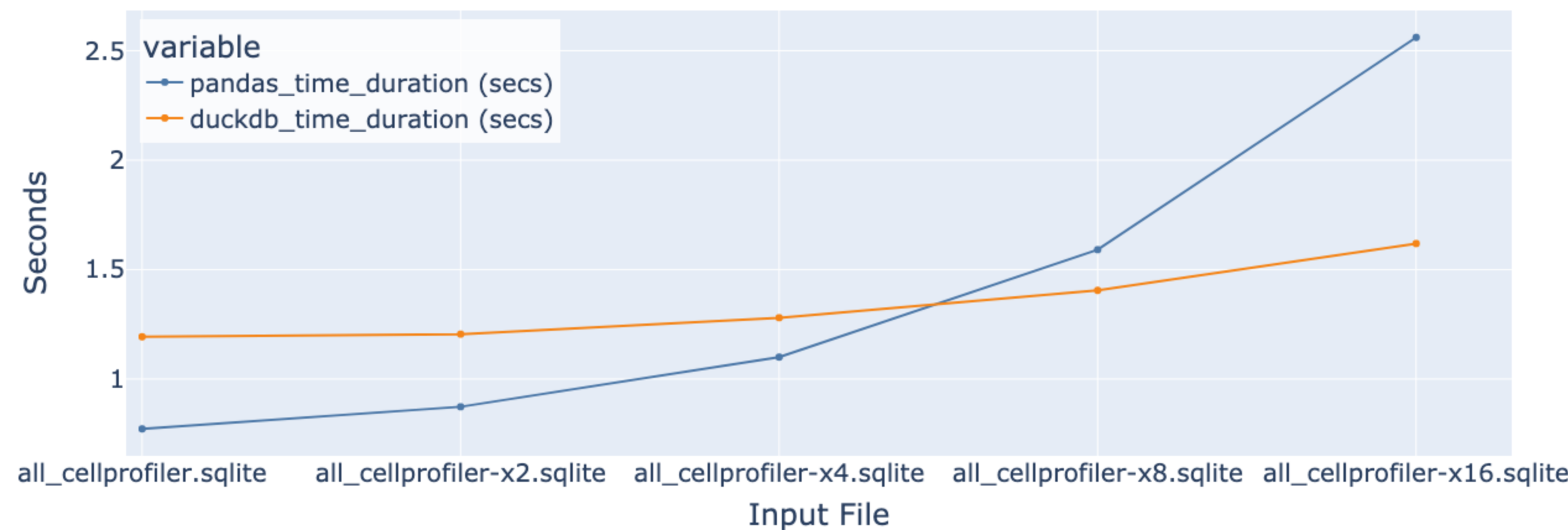


Figure 4. Chart showing read time durations of Pandas and DuckDB with SQLite databases of various sizes.

Structured Query Language (SQL) through [DuckDB](#) provides an Arrow-compatible embedded database system optimized for vectorized execution. DuckDB delivers in-memory capabilities through SQL, treating variable data as a loose collection of database tables without needing conversion.

Output: Apache Parquet

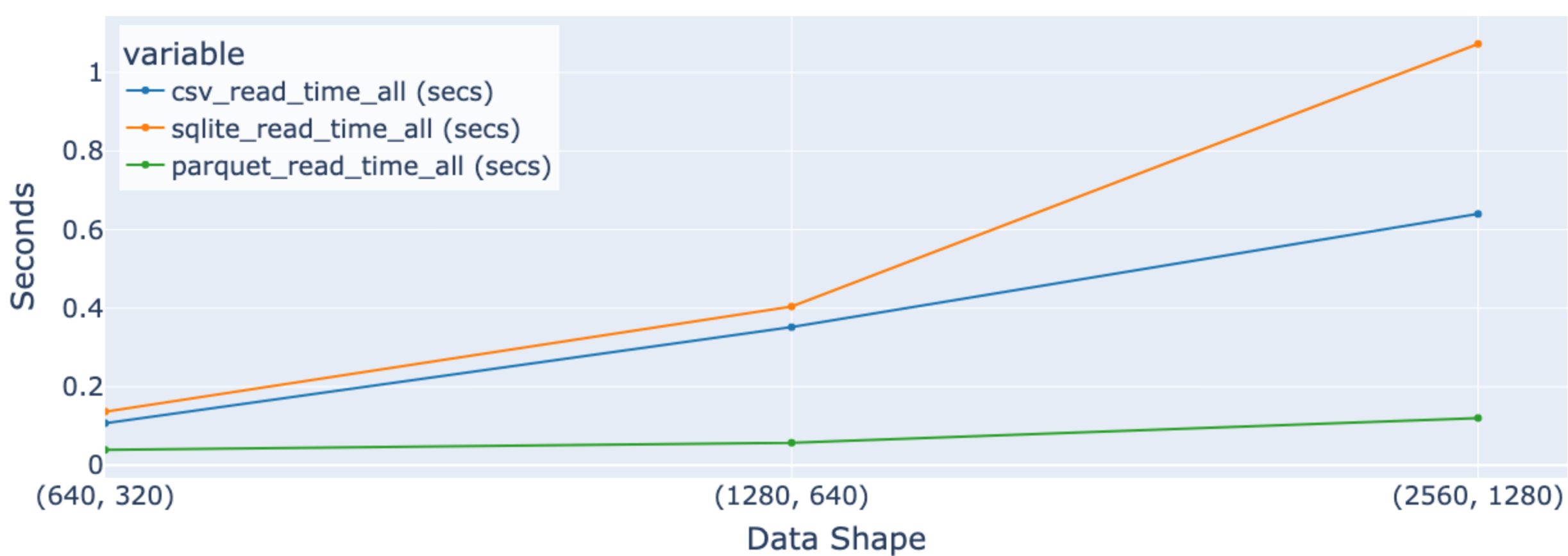


Figure 5. Chart showing read time durations for data from various file formats.

Work is saved in [Apache Parquet](#) files, which are compatible with Apache Arrow, and designed for storage and retrieval efficiency. Parquet is a columnar data format which may be partitioned across one or many files.

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- The Broad Institute (<https://www.broadinstitute.org/>)