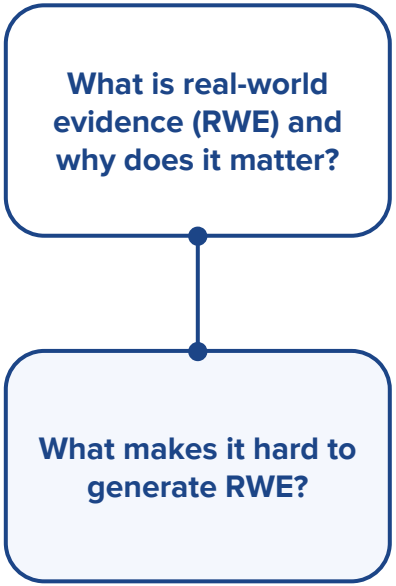
Accelerating privacy-enhancing data processing

Florian Stefan

Staff Software Engineer @ Flatiron Health

What is real-world evidence (RWE) and why does it matter?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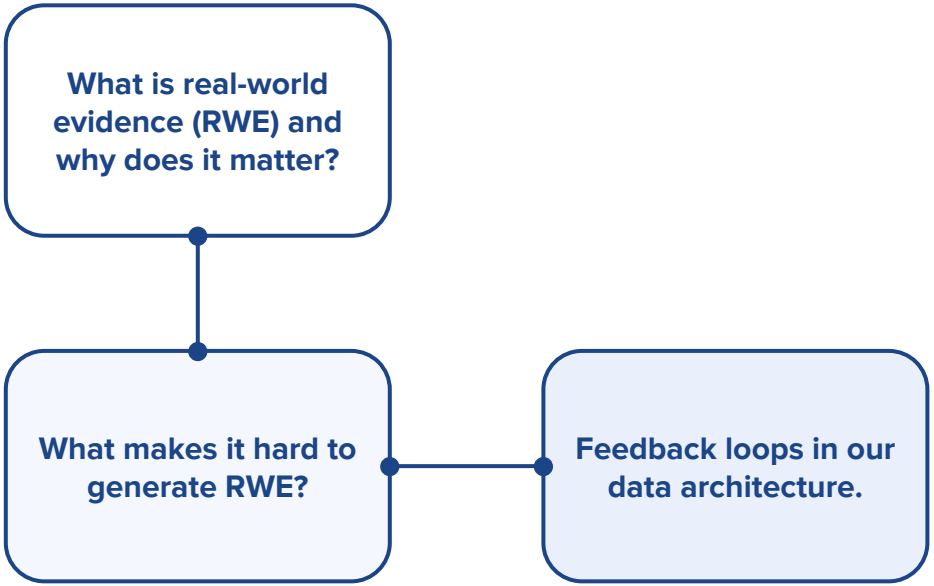
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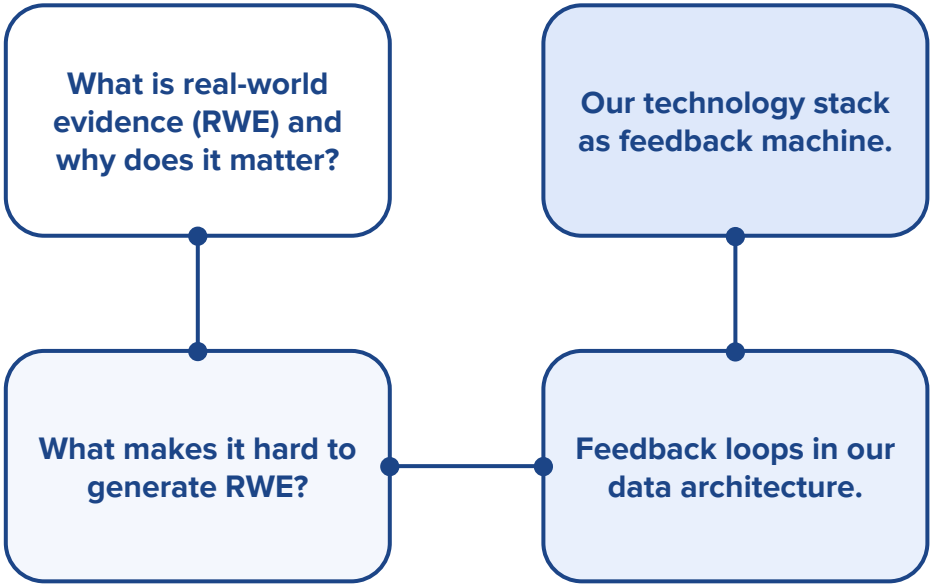
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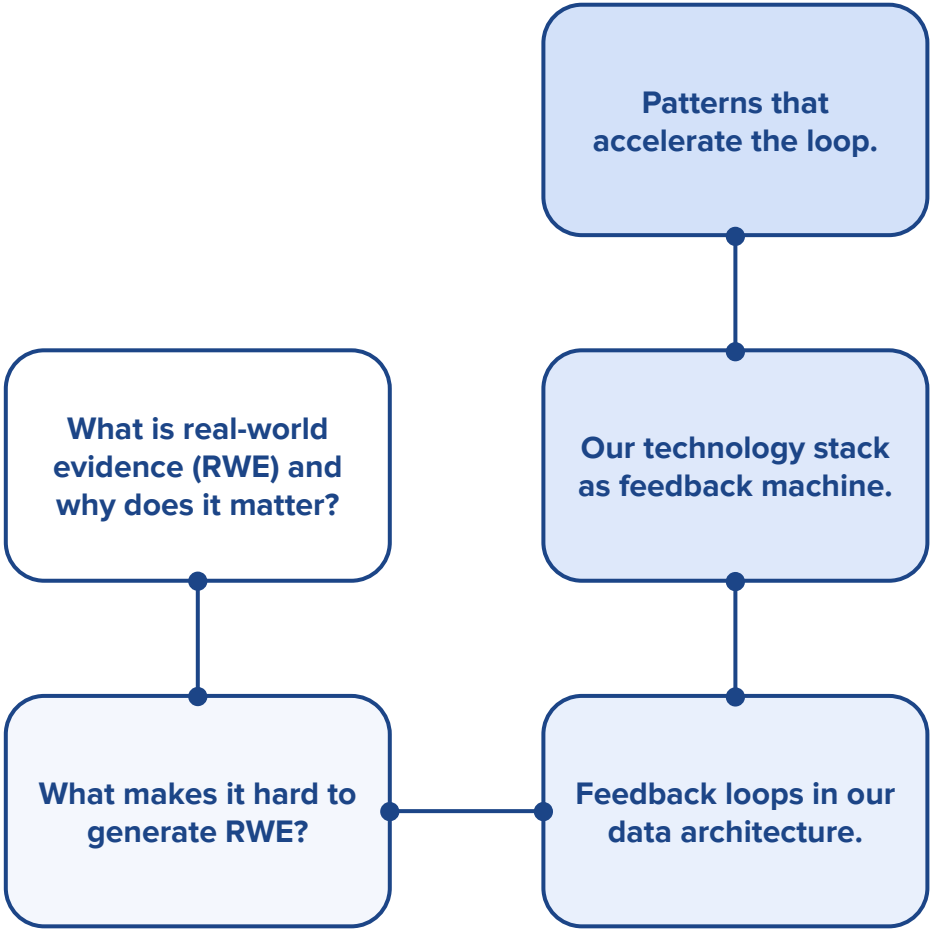
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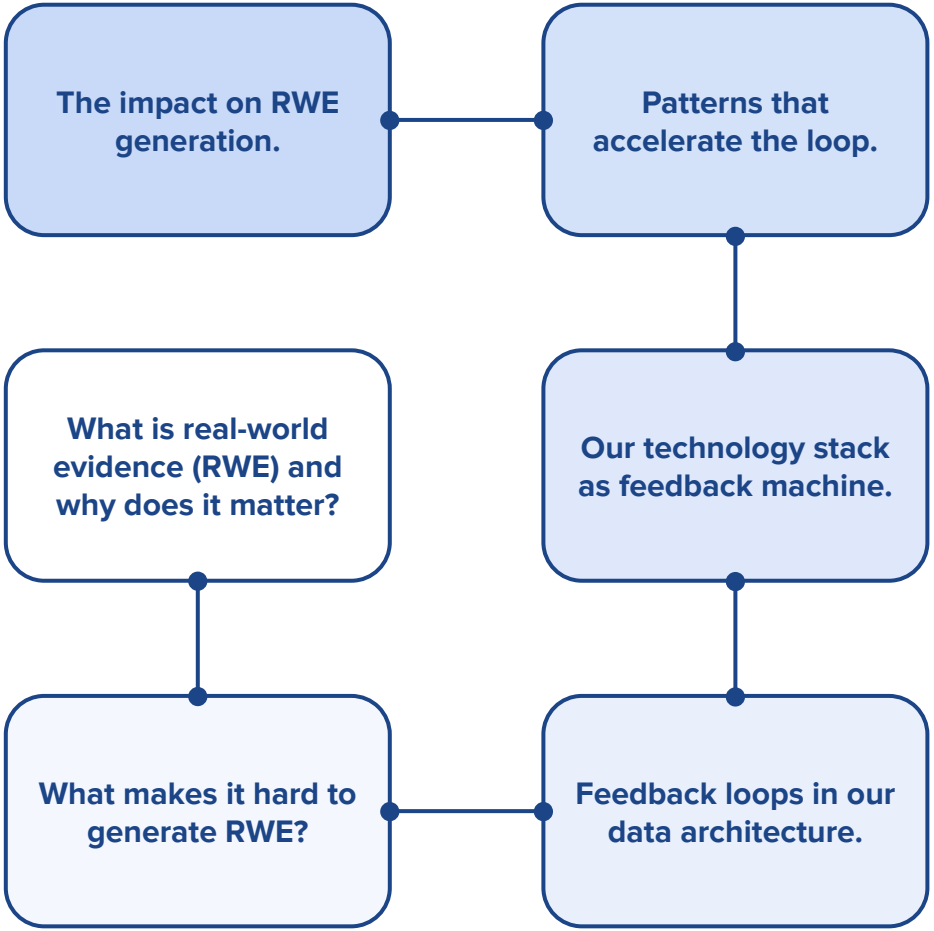
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Generated from clinical data collected during routine care.

- Data sources include EHRs, laboratory systems, and cancer registries.
- Combines structured and unstructured data across the healthcare ecosystem.

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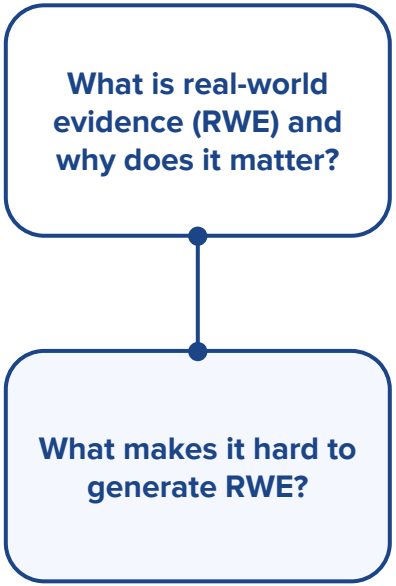
- Combines structured and unstructured data across the healthcare ecosystem.

Supports research, regulatory, and clinical decision-making.

- Enables faster and more cost-effective evidence generation.
- Captures real-world treatment outcomes ...
- ... across diverse populations, therapies, and care settings.

What is real-world evidence (RWE) and why does it matter?



Fragmented and heterogeneous data landscape.

- Data is siloed across institutions, formats, and systems.
- Lack of standards for structuring clinical observations.

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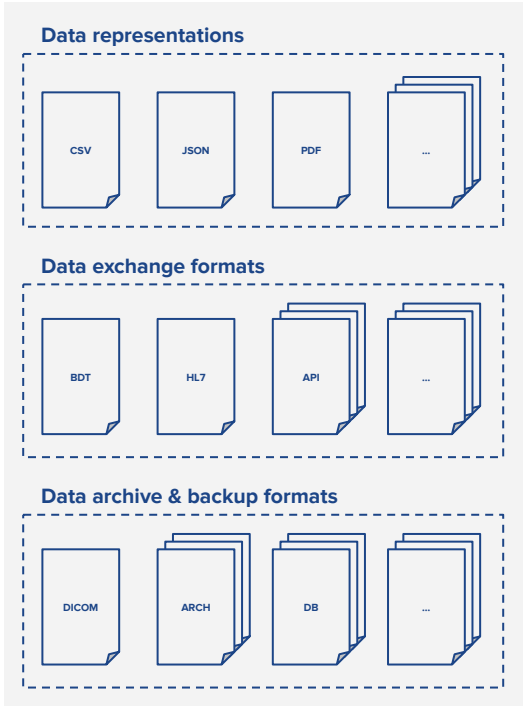

Fragmented and heterogeneous data landscape.

- Data is siloed across institutions, formats, and systems.
- Lack of standards for structuring clinical observations.

Unstructured, incomplete, and noisy data.

- Critical information often buried in free text, scans, or PDFs.
- Requires OCR, NLP, and manual abstraction to extract meaning.

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Patient: Maria T. (DOB: 1966-04-23, MRN: 872394)
Hx: mCRC, T3N2M1, KRAS-mut, DM2, HTN

Pt seen today with daughter for f/u. Reports stable appetite, mild fatigue.
Completed 8 cycles FOLFOX + Bev — PD on 8/30/2023 CT (incr. liver mets, new pulm nodule).
Plan: switch to FOLFIRI + Bev, pending ANC >1.0 + plt >100.
Labs drawn today; port to be placed Thursday (9/21).

Avoid steroids due to poorly controlled DM2 (last A1c: 9.3%).
Will start antiemetics (ondansetron PRN; consider olanzapine).
Imaging planned for 11/13/2023 to assess response.

Discussed goals of care. Pt wants to continue active tx, prefers to be treated at clinic near home in Trenton if possible.

Note dictated by Dr. Klein, 9/18/2023 at 17:42.

Test	Value	Units
WBC	5.6	$\times 10^9$/L
ANC	0.8	$\times 10^9$/L
HbA1c (from 09/01)	9.3	%

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Strict regulatory and privacy constraints.

- Patient data must be handled with strong privacy protections.
- Access and re-use often restricted across organizations.

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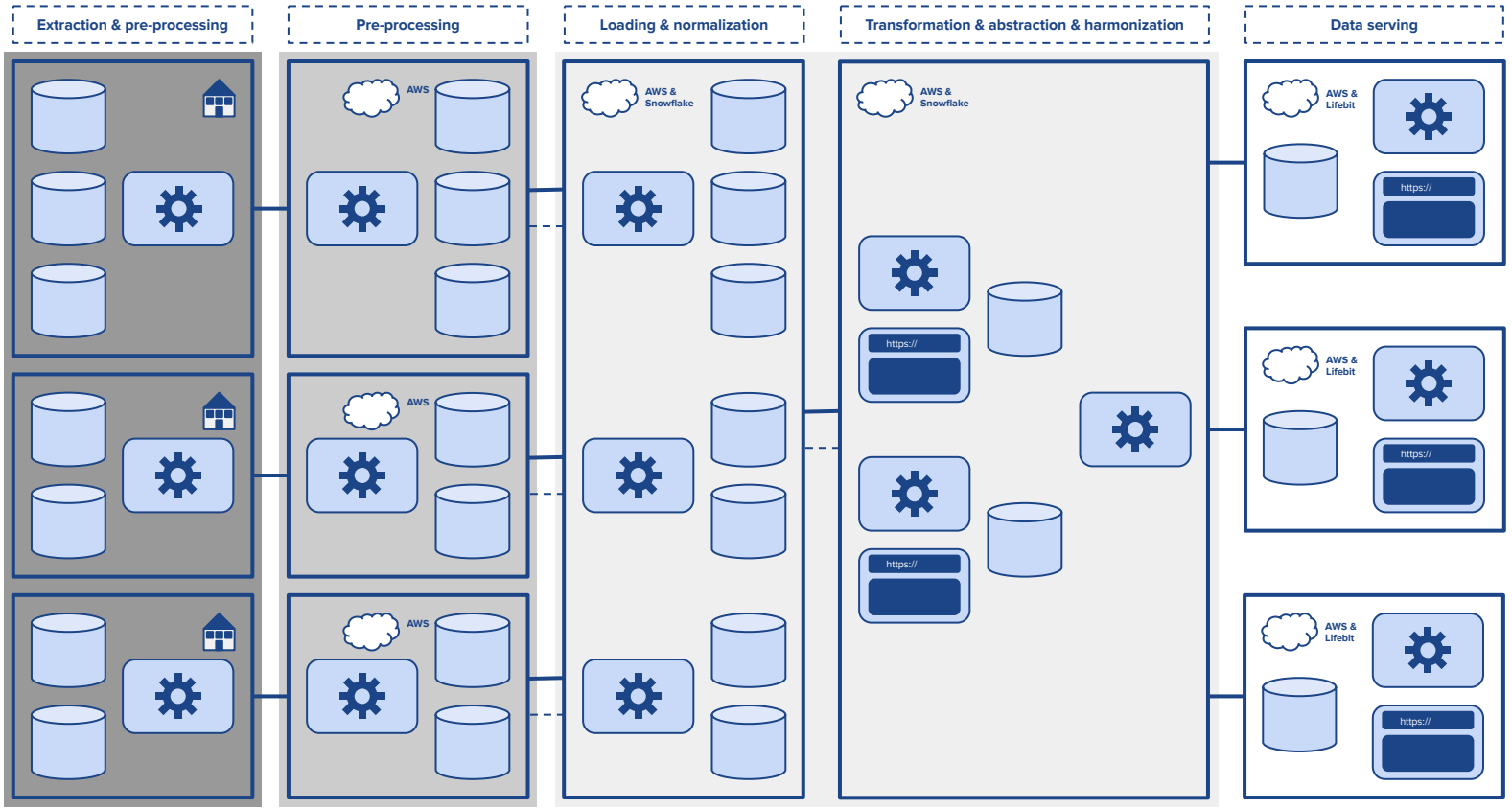
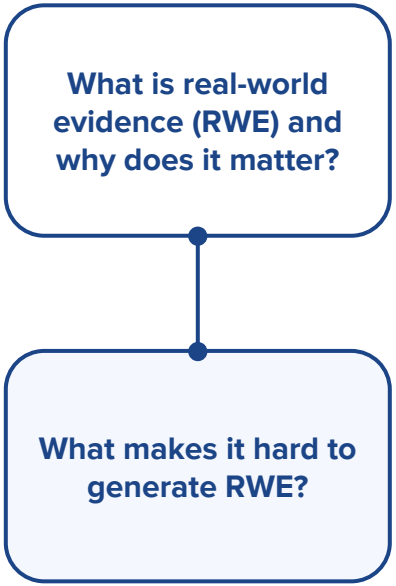
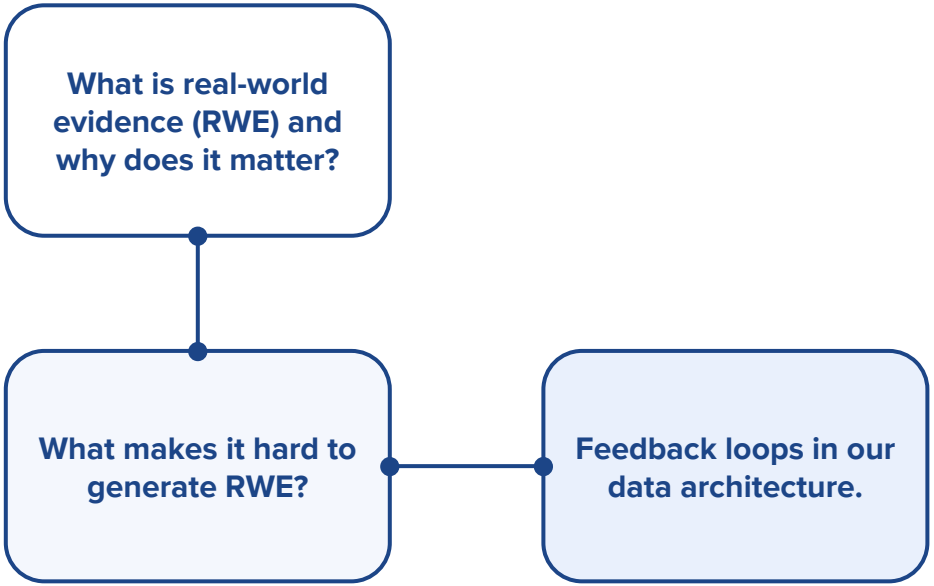
Increasing privacy levels







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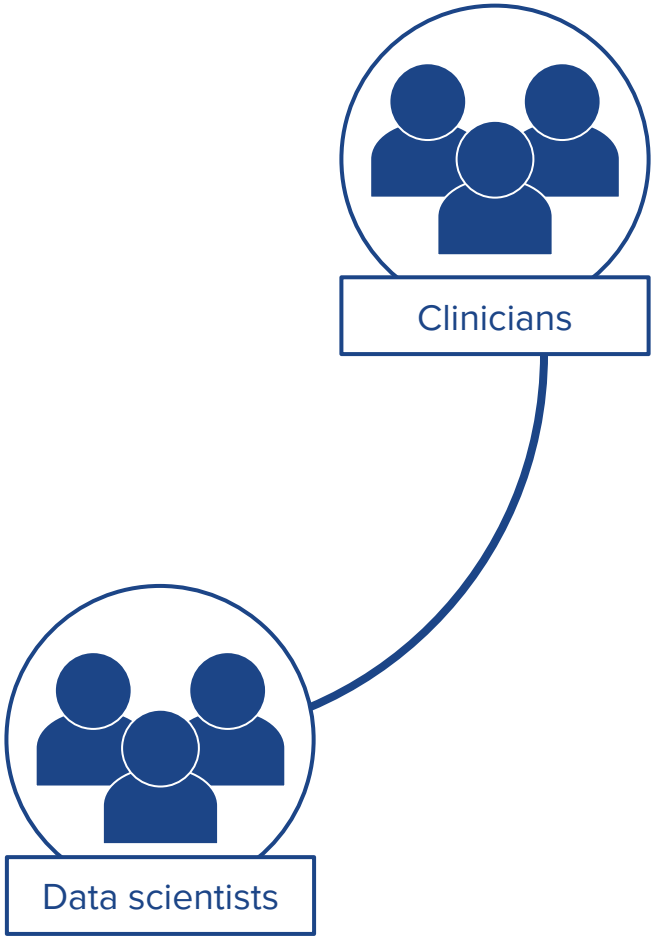

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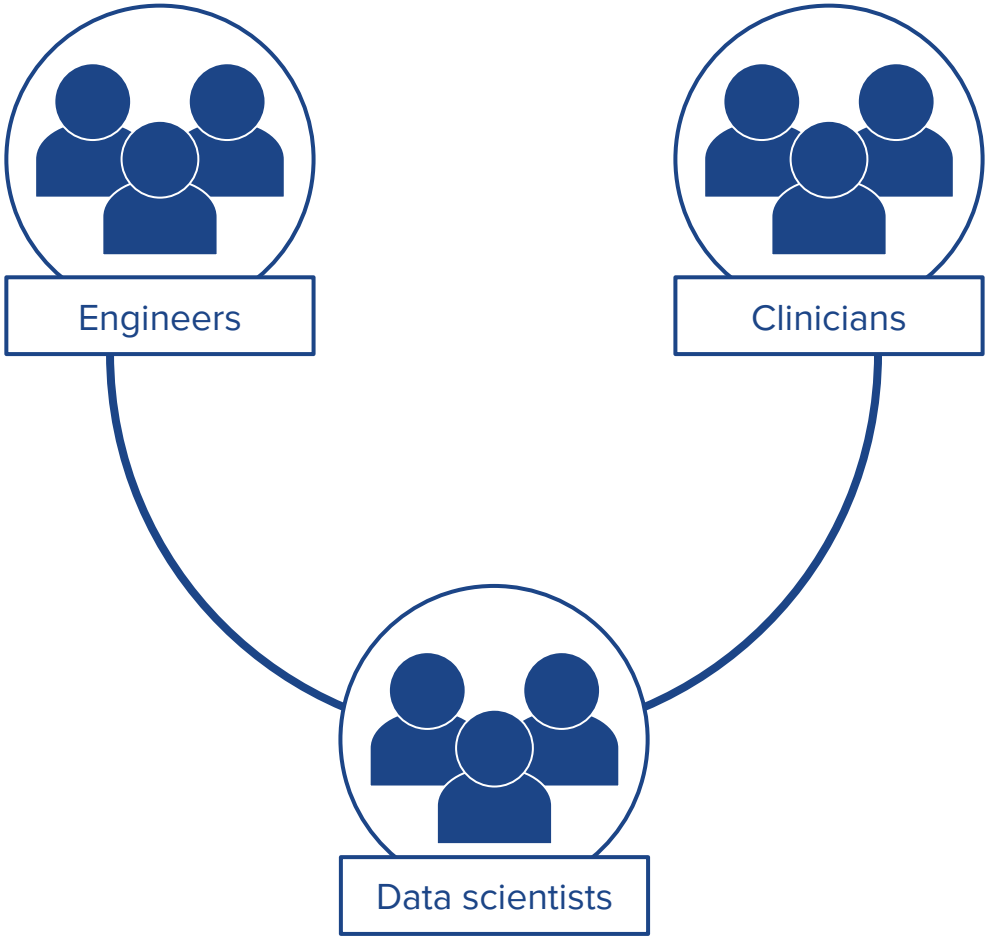

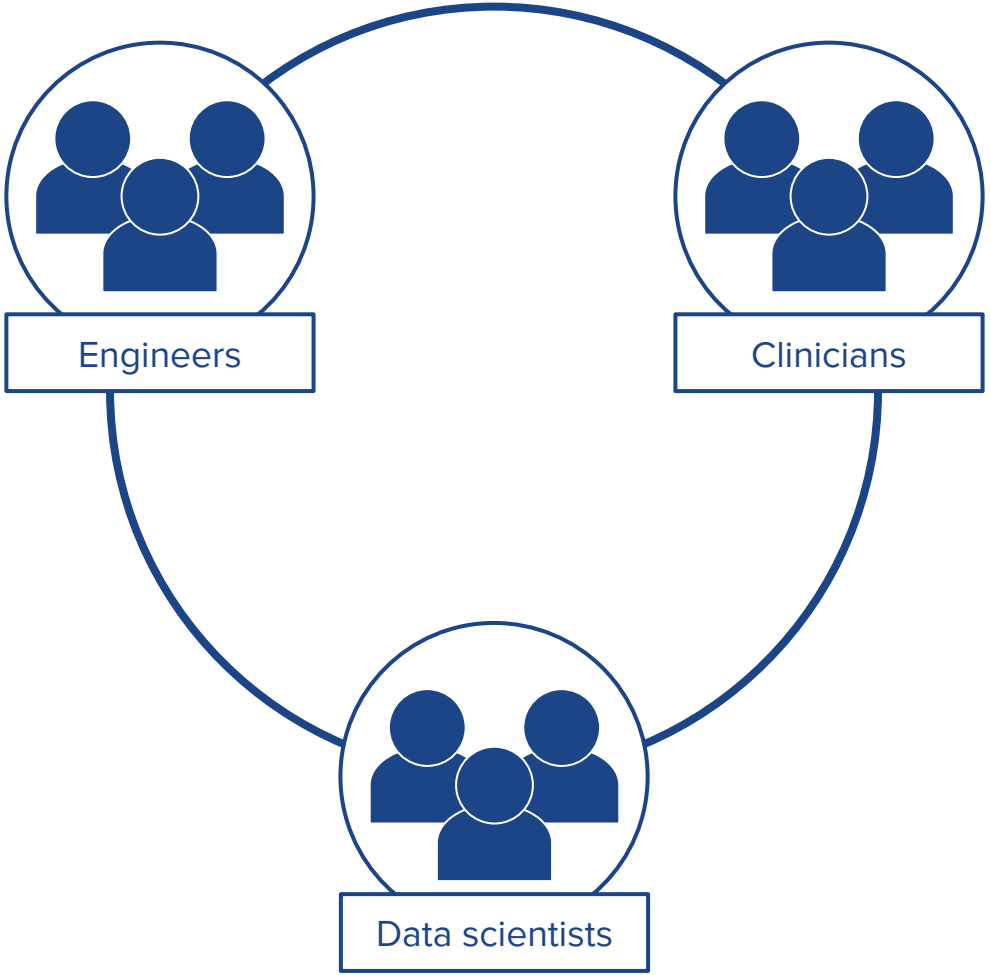

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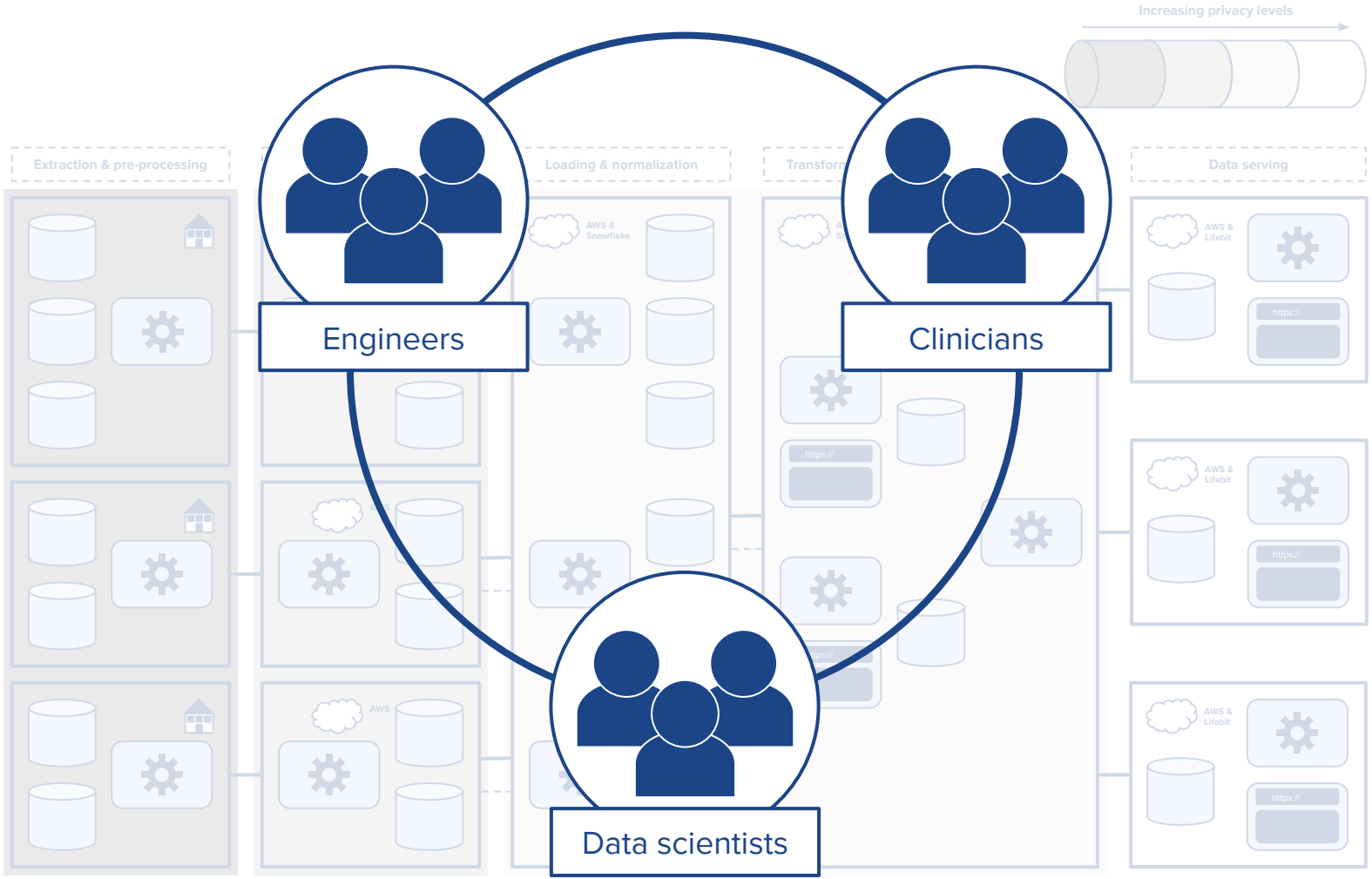

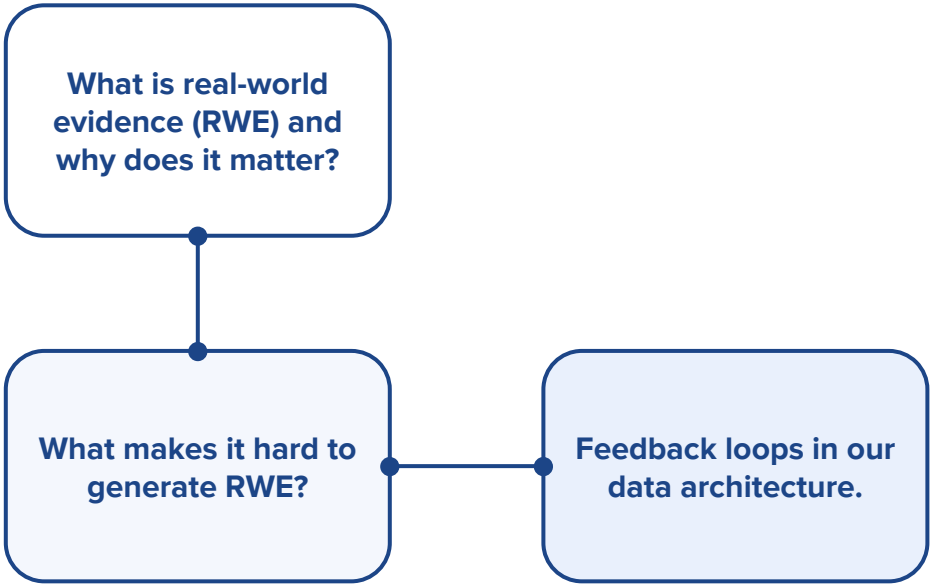

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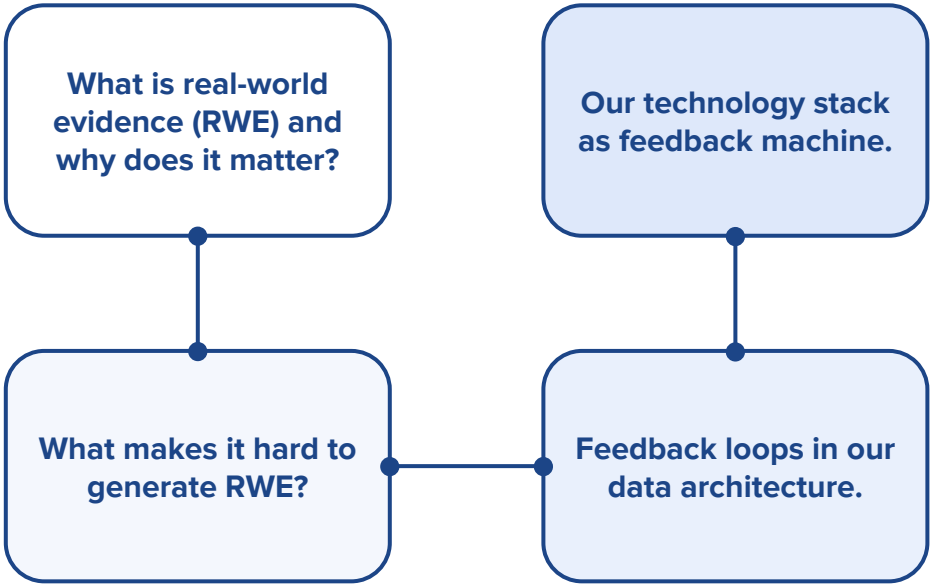

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poetry add dagster dagster-dbt
poetry add dbt-snowflake
poetry add "dlt[s3,snowflake]"
poetry add "ibis-framework[snowflake]"
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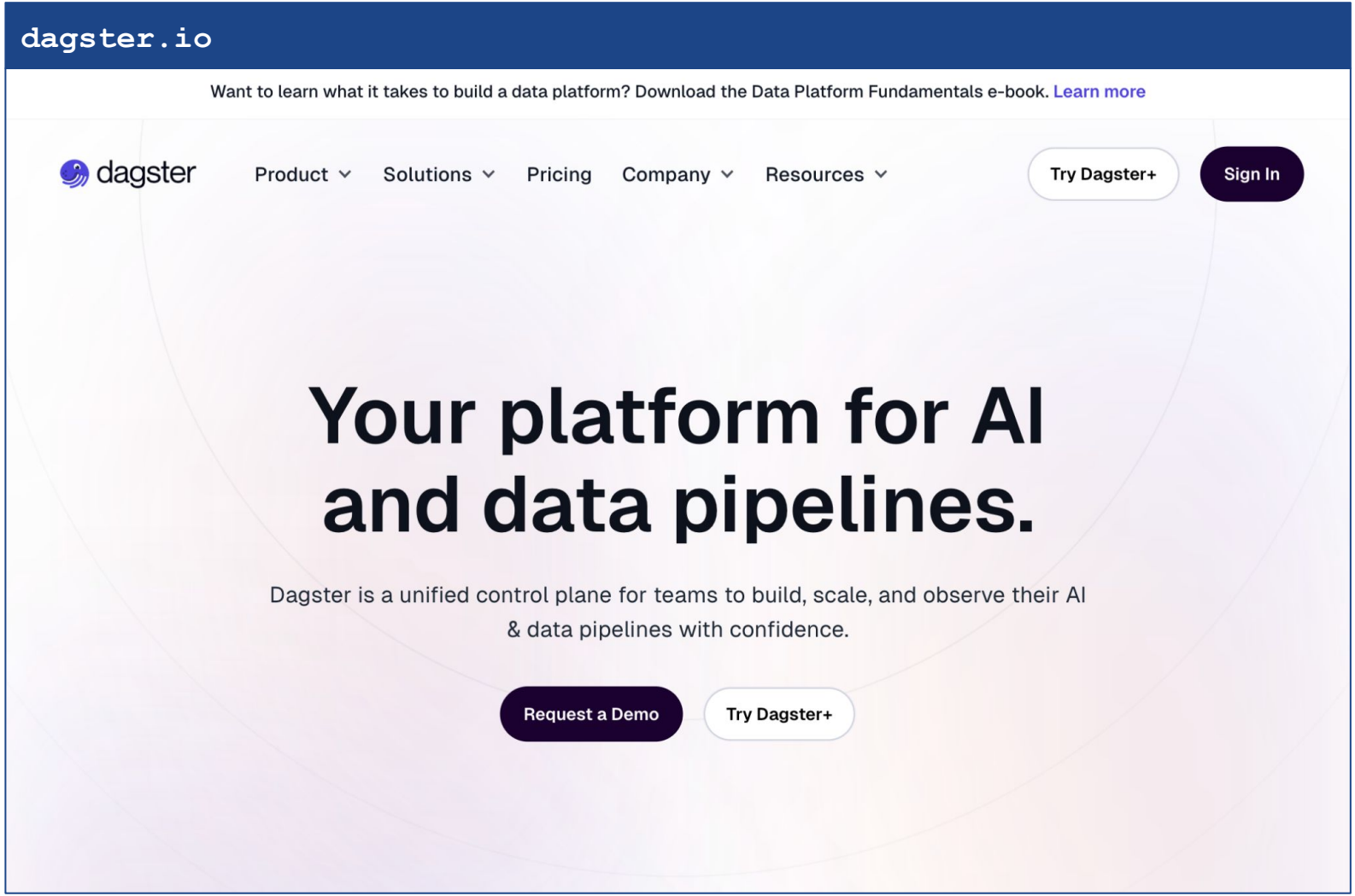

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getdbt.com

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The modern standard for data transformation.

dbt turns data work into a shared, scalable practice by bringing the best of software engineering to the analytics workflow.

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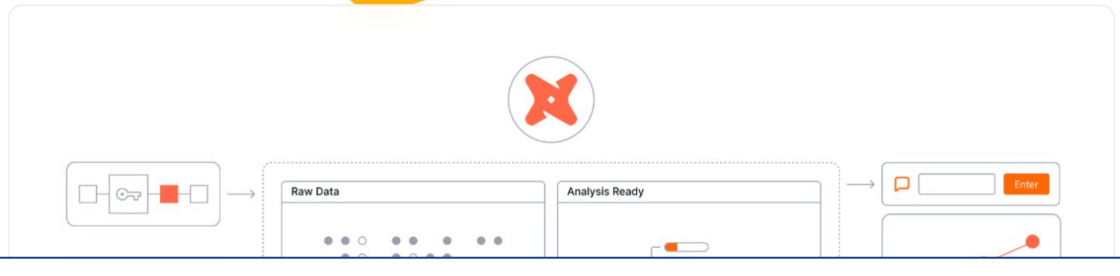

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```
open "https://dlthub.com"
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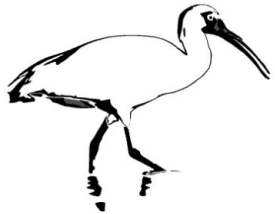
ibis-project.org

Ibis | Getting started | Concepts | Backends | How-to | Reference | Posts | Presentations | Release notes | Contribute



Ibis

the portable Python dataframe library

Why Ibis? | Installation | 10 minutes to Ibis | Blog | GitHub | Chat | RSS

An open source dataframe library that works with any data system

- Use the same API for nearly 20 backends
- Fast local dataframes with embedded DuckDB (default), Polars, or DataFusion
- Iterate locally and deploy remotely by changing a single line of code
- Compose SQL and Python dataframe code, bridging the gap between data engineering and data science

Ibis: the portable Python dataframe library

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```
@dlt.transformer(standalone=True)
def bdt_transformer(items):
    ...


@dlt.source
def john_doe_clinic_bdt_dlt_source():
    return filesystem(bucket_url=...) | bdt_transformer()


@asset
def john_doe_clinic_bdt_dlt_source_asset(dlt: DltResource):
    source_schema = os.environ["JOHN_DOE_CLINIC_BDT_SOURCE_SCHEMA"]

    dlt.pipeline(source_schema).run(john_doe_clinic_bdt_dlt_source())


class DltResource(ConfigurableResource):
    def pipeline(self, source_schema):
        return dlt.pipeline(
            destination="snowflake",
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```
nano models/src/john_doe_clinic/bdt.yml
```

nano

```
version: 2

sources:
  - name: john_doe_clinic_bdt
    database: '{{ env_var("SOURCE_DATABASE") }}'
    schema: '{{ env_var("JOHN_DOE_CLINIC_BDT_SOURCE_SCHEMA") }}'
    tables:
      - ...
      - name: _6200___6200
        meta:
          dagster:
            asset_key: john_doe_clinic_bdt__6200___6200
      - name: _6200___6200___8401
        meta:
          dagster:
            asset_key: john_doe_clinic_bdt__6200___6200___6200___8401
      - name: _6200___6200___8401___8410
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      - name: _6200___6200___8401___8410
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def john_doe_clinic_bdt_dbt_source_table_asset_factory():
    for asset_key in asset_keys("john_doe_clinic/bdt.yml"):
        @asset(name=asset_key, deps=[john_doe_clinic_bdt_dlt_source_asset])
        def dbt_source_table_asset():
            pass

        yield dbt_source_table_asset
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    for asset_key in asset_keys("john_doe_clinic/bdt.yml"):
        @asset(name=asset_key, deps=[john_doe_clinic_bdt_dlt_source_asset])
        def dbt_source_table_asset():
            pass

        yield dbt_source_table_asset
```

The impact on RWE generation.

Patterns that accelerate the loop.

Our technology stack as feedback machine.

Feedback loops in our data architecture.

What makes it hard to generate RWE?

What is real-world evidence (RWE) and why does it matter?

-zsh

```
nano models/stg/john_doe_clinic/john_doe_clinic_lab.sql
```

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nano

```
select
    ...,
    to_date(cast(_8432__value as varchar), 'DDMMYYYY') as test_date,
    ...
from source("john_doe_clinic_bdt", "_6200___6200") as _6200
join source("john_doe_clinic_bdt", "_6200___6200___8401") as _8401
    on _6200._dlt_id = _8401._dlt_parent_id
left join source("john_doe_clinic_bdt", "_6200___6200___8401___8410") as _8410
    on _8401._dlt_id = _8410._dlt_parent_id
```

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    ...,
    to_date(cast(_8432__value as varchar), 'DDMMYYYY') as test_date,
    ...
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join source("john_doe_clinic_bdt", "_6200___6200___8401") as _8401
    on _6200._dlt_id = _8401._dlt_parent_id
left join source("john_doe_clinic_bdt", "_6200___6200___8401___8410") as _8410
    on _8401._dlt_id = _8410._dlt_parent_id
```

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```
poetry run dbt compile --profile="snowflake"
```

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-zsh

```
nano definitions.py
```

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nano

```
@dbt_assets(manifest=Path(...) / "manifest.json")
def dbt_model_assets(context: AssetExecutionContext, dbt: DbtCliResource):
    yield from dbt.cli(["build"], context=context).stream()
```

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nano

```
@dbt_assets(manifest=Path(...) / "manifest.json")
def dbt_model_assets(context: AssetExecutionContext, dbt: DbtCliResource):
    yield from dbt.cli(["build"], context=context).stream()
```

nano

```
@asset(deps=[dbt_model_assets])
def john_doe_clinic_lab_harmonized_asset(ibis: IbisResource):
    with ibis.session() as session:
        table = session.table(...)

        for index, rows in enumerate(table.to_pandas_batches()):
            harmonized_rows = ...

            if index == 0:
                session.create_table(..., obj=harmonized_rows, overwrite=True)
            else:
                session.insert(..., obj=harmonized_rows, overwrite=False)


class IbisResource(ConfigurableResource):
    @contextmanager
    def session(self):
        connection = ibis.snowflake.connect(...)

        try:
            yield connection
        finally:
            connection.disconnect()
```

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nano

```
defs = Definitions(
    assets=[
        john_doe_clinic_bdt_dlt_source_asset,
        *john_doe_clinic_bdt_dbt_source_table_asset_factory(),
        dbt_model_assets,
        john_doe_clinic_lab_harmonized_asset,
    ],
    resources={
        "dbt": DbtCliResource(project_dir=..., profile="snowflake"),
        "dlt": DltResource(),
        "ibis": IbisResource(),
    },
)
```

nano

```
defs = Definitions(
    assets=[
        john_doe_clinic_bdt_dlt_source_asset,
        *john_doe_clinic_bdt_dbt_source_table_asset_factory(),
        dbt_model_assets,
        john_doe_clinic_lab_harmonized_asset,
    ],
    resources={
        "dbt": DbtCliResource(project_dir=..., profile="snowflake"),
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-zsh

```
poetry run dagster asset materialize -f definitions.py --select "*"
```

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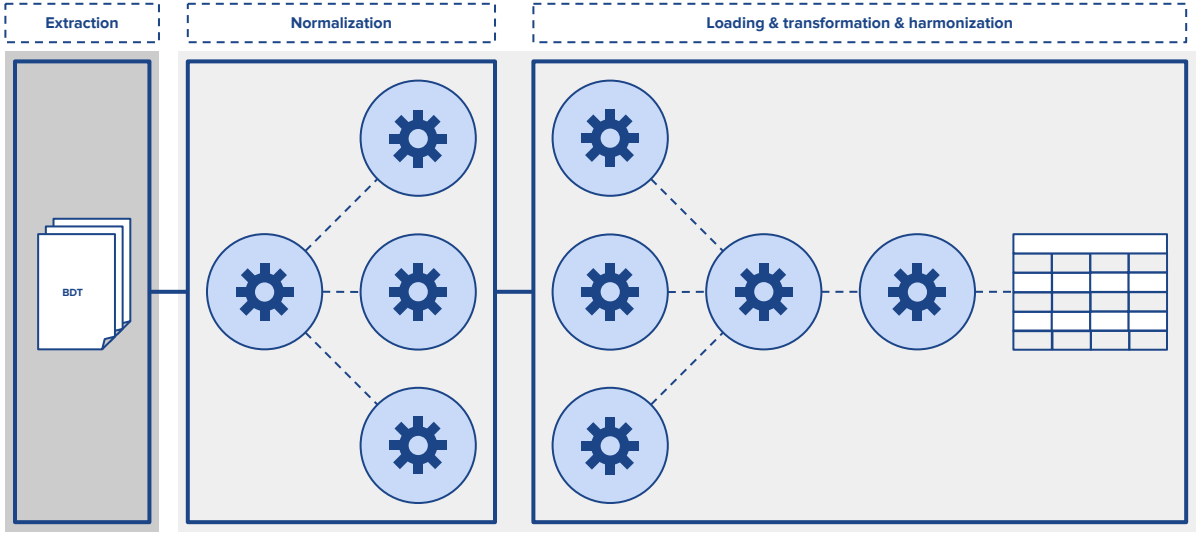
```



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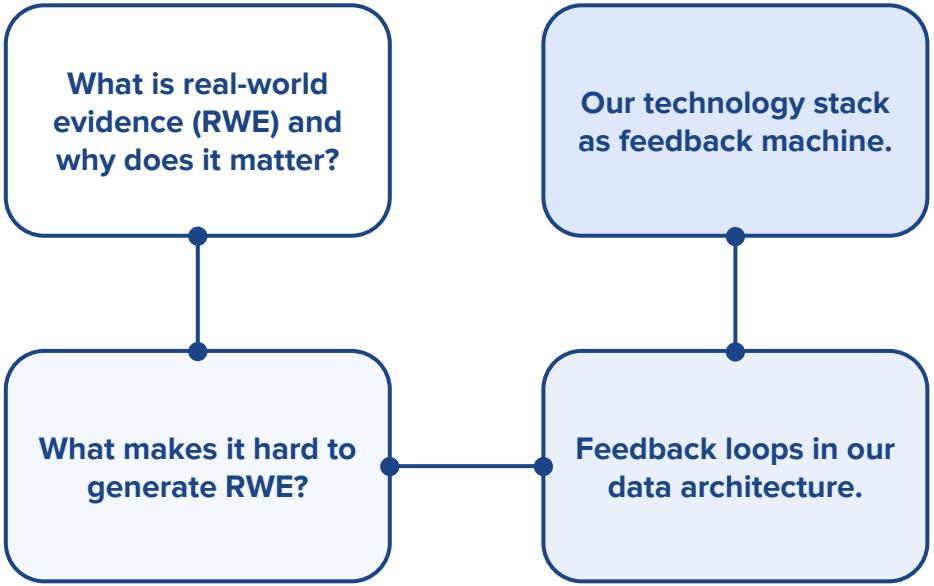

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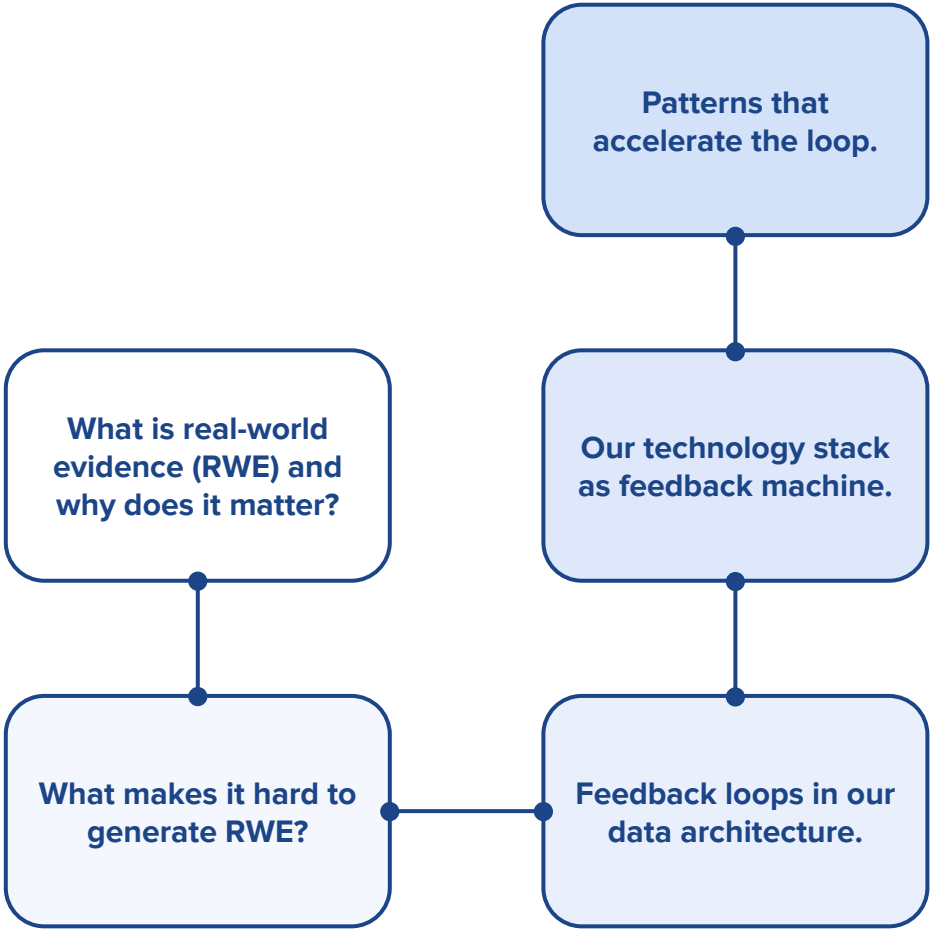

Shift testing left.

- Test pyramid: Unit tests, integrity tests, regression tests, cohort tests
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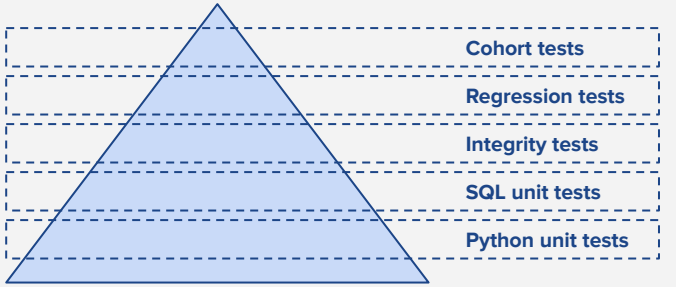

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-zsh

```
nano models/stg/john_doe_clinic/john_doe_clinic_lab.yml
```

nano

```
version: 2

models:
  - name: john_doe_clinic_lab
    columns:
      - name: test
        data_tests:
          - expect_row_count_quantiles_to_be_greater_than_or_equal_to:
              filter: ...
              cohort_filter: ...
              row_count_quantiles: ...
```

nano

```
version: 2

models:
  - name: john_doe_clinic_lab
    columns:
      - name: test
        data_tests:
          - expect_row_count_quantiles_to_be_greater_than_or_equal_to:
              filter: ...
              cohort_filter: ...
              row_count_quantiles: ...
```

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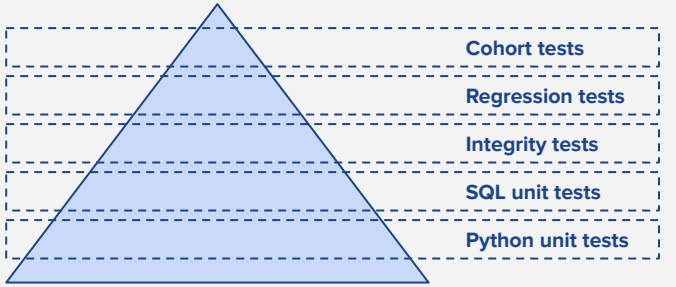

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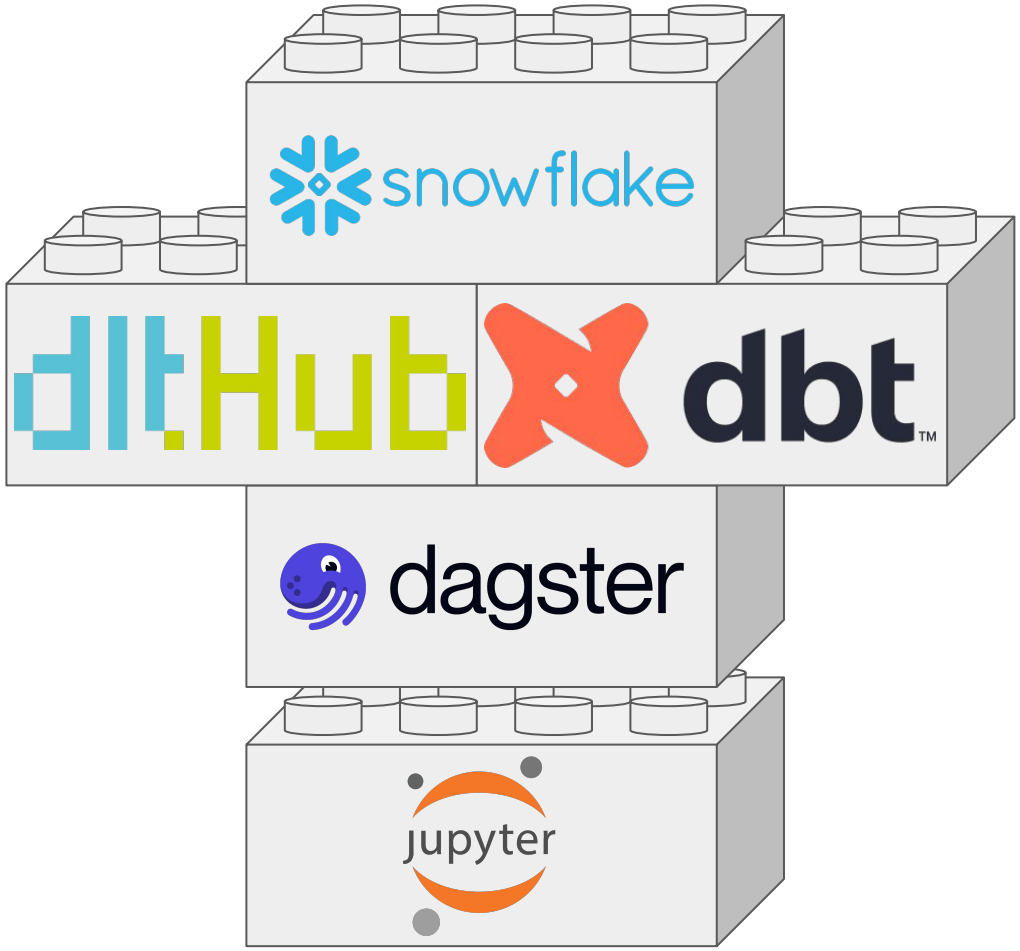

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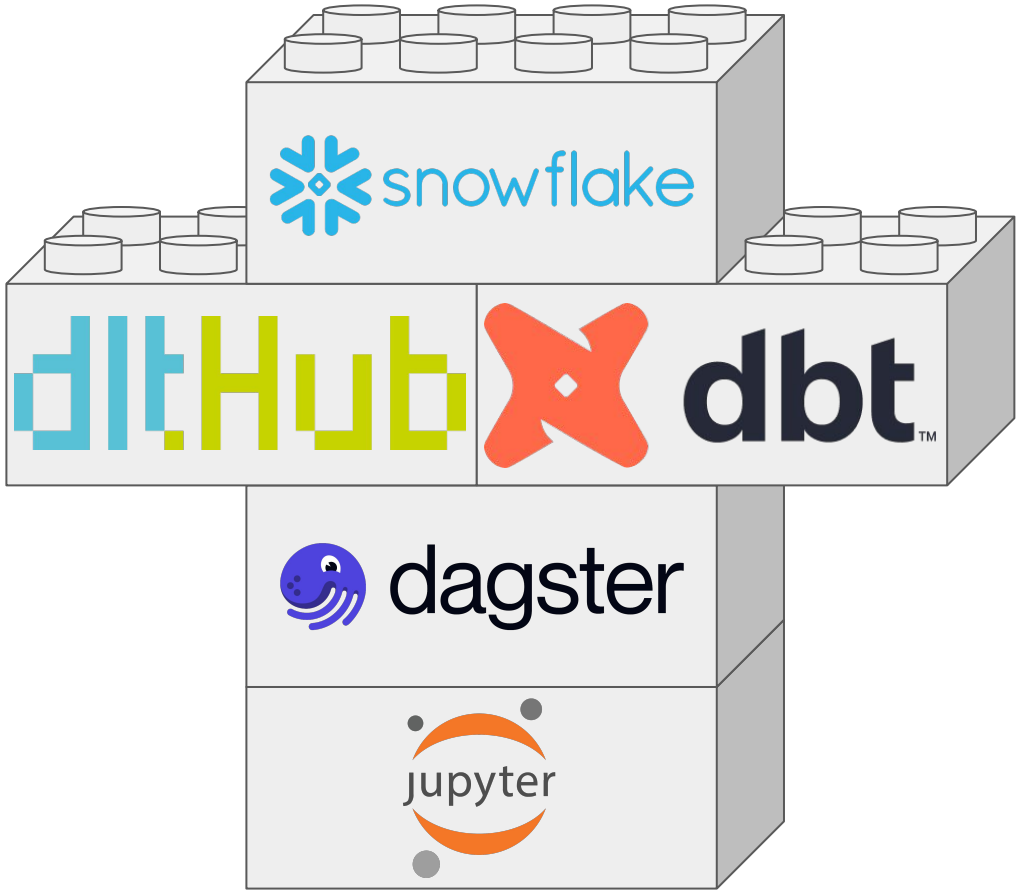

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-zsh

```
poetry add ipykernel
poetry run python -m ipykernel install --user --name ... --display_name ...
```

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```
-zsh

open "https://jupyter-4xzv.notebook.eu-central-1.sagemaker.aws/lab"
```

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jupyter-4xzv.notebook.eu-central-1.sagemaker.aws/lab

```
import dagster, definitions
```

```
@asset(deps=[definitions.dbt_model_assets])
def john_doe_clinic_lab_harmonized_asset(ibis: definitions.IbisResource):
    ...
```

```
dagster.materialize(
    assets=[
        definitions.john_doe_clinic_bdt_dlt_source_asset,
        *definitions.john_doe_clinic_bdt_dbt_source_table_asset_factory(),
        definitions.dbt_model_assets,
        john_doe_clinic_lab_harmonized_asset,
    ],
    resources={
        ...
    }
)
```

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    ...
```

```
dagster.materialize(
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        ...
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)
```

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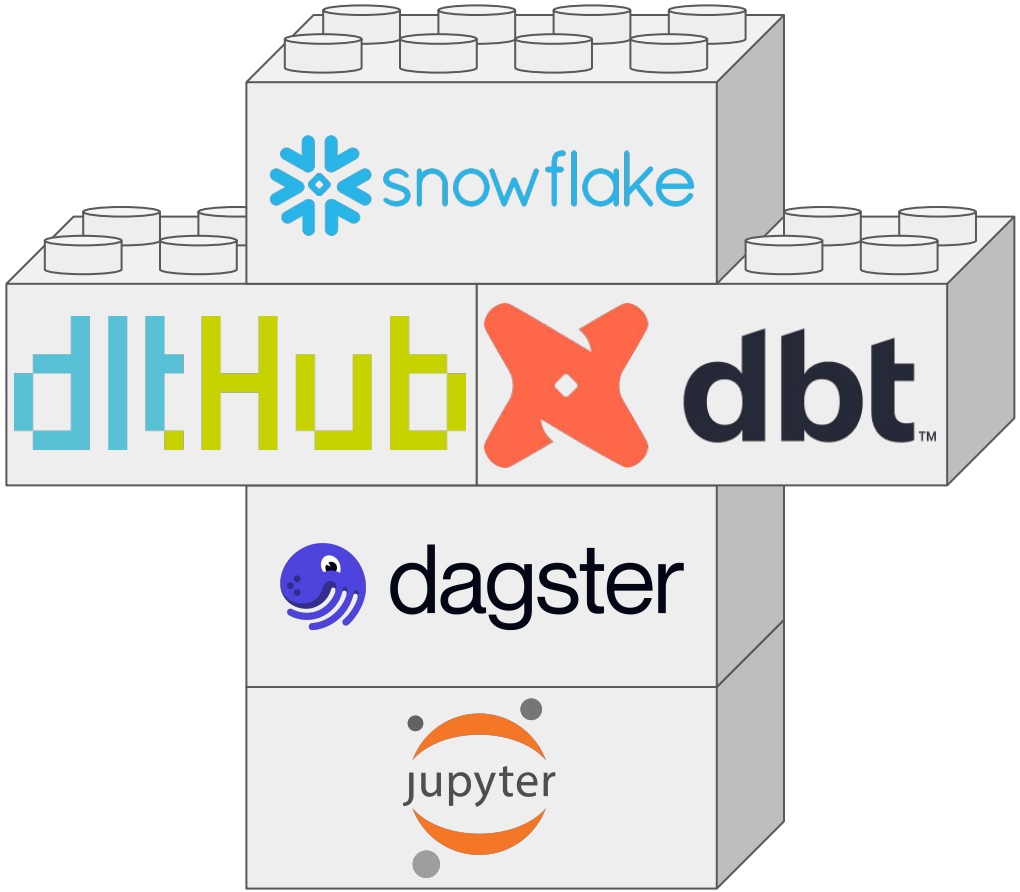

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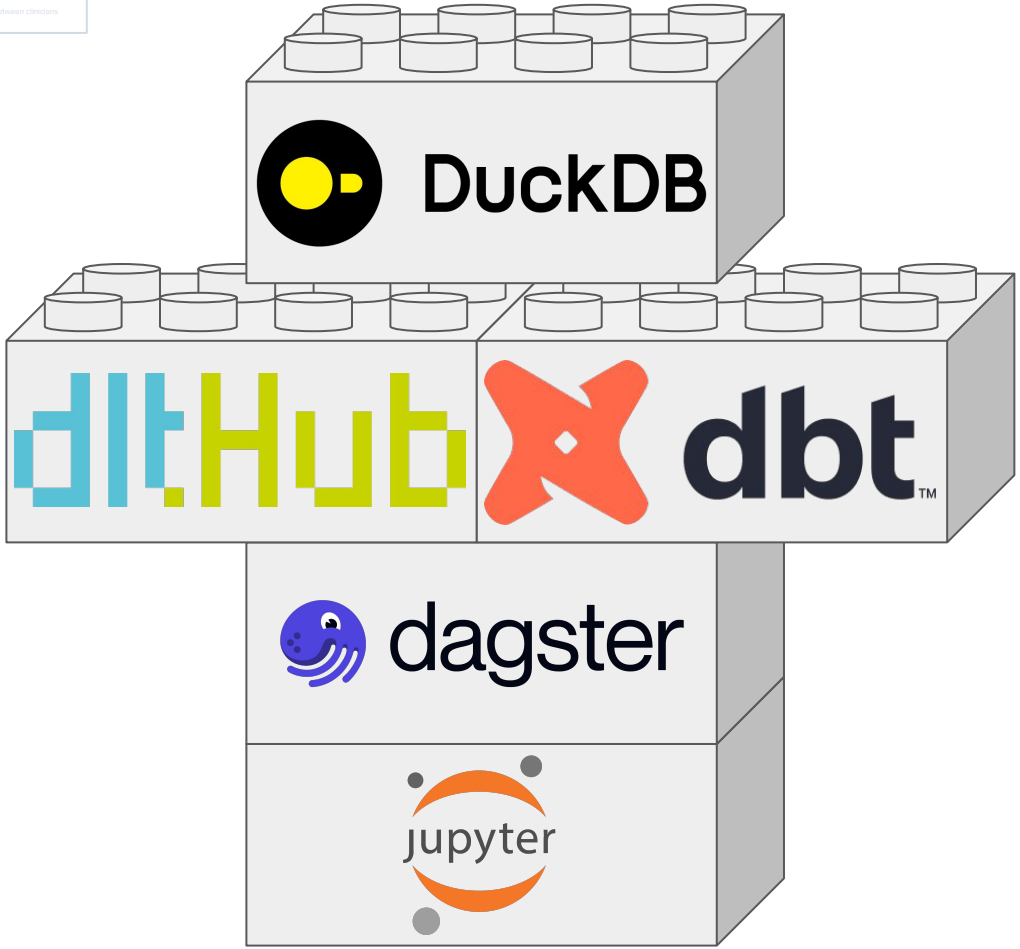

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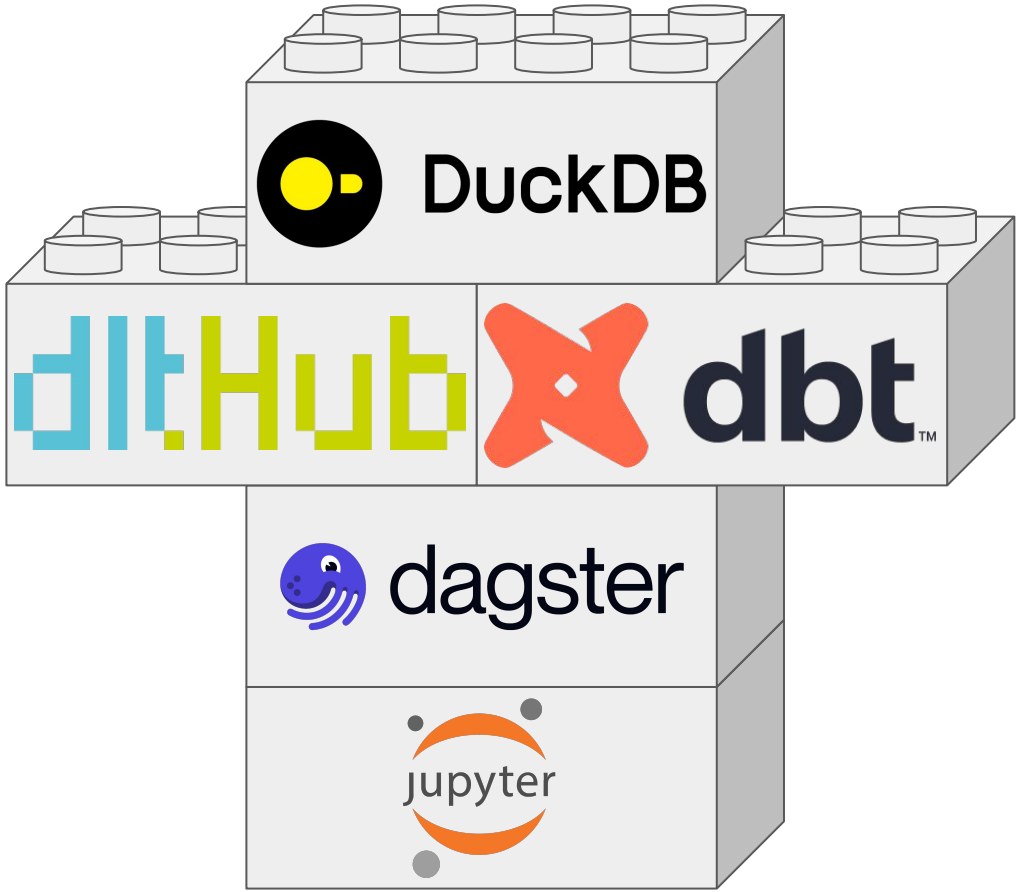

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-zsh

```
poetry add dbt-duckdb
poetry add "dlt[duckdb,s3]"
poetry add "ibis-framework[duckdb]"
```

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```
-zsh

open "https://duckdb.org"
```

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duckdb.org

DuckDB

Documentation Resources GitHub 29.6k Support

We have released DuckLake, a SQL-as-a-lakehouse standard. Read the announcement blog post.

DuckDB is a fast analytical database system

Query and transform your data anywhere using DuckDB's feature-rich SQL dialect

Installation ↓ Documentation

SQL Python R Java Node.js

```sql
-- Get the top-3 busiest train stations
SELECT
    station_name,
    count(*) AS num_services
FROM train_services
GROUP BY ALL
ORDER BY num_services DESC
LIMIT 3;
```

Aggregation query Live demo →

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nano

```
class DltResource(ConfigurableResource):
    def pipeline(self, source_schema):
        return dlt.pipeline(
            destination="duckdb",
            dataset_name=source_schema
        )
```

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    def pipeline(self, source_schema):
        return dlt.pipeline(
            destination="duckdb",
            dataset_name=source_schema
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-zsh

```
nano models/stg/john_doe_clinic/john_doe_clinic_lab.sql
```

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nano

```
select
    ...,
    {{ to_date("_8432__value", "DDMMYYYY") }} as test_date,
    ...
from source("john_doe_clinic_bdt", "_6200___6200") as _6200
join source("john_doe_clinic_bdt", "_6200___6200___8401") as _8401
    on _6200._dlt_id = _8401._dlt_parent_id
left join source("john_doe_clinic_bdt", "_6200___6200___8401___8410") as _8410
    on _8401._dlt_id = _8410._dlt_parent_id
```

nano

```
select
    ...,
    {{ to_date("_8432__value", "DDMMYYYY") }} as test_date,
    ...
from source("john_doe_clinic_bdt", "_6200___6200") as _6200
join source("john_doe_clinic_bdt", "_6200___6200___8401") as _8401
    on _6200._dlt_id = _8401._dlt_parent_id
left join source("john_doe_clinic_bdt", "_6200___6200___8401___8410") as _8410
    on _8401._dlt_id = _8410._dlt_parent_id
```

The impact on RWE generation.

Patterns that accelerate the loop.

Our technology stack as feedback machine.

Feedback loops in our data architecture.

What makes it hard to generate RWE?

What is real-world evidence (RWE) and why does it matter?

-zsh

```
nano macros/dialects/to_date.sql
```

nano

```
{% macro to_date(column, format) %}
    {{ return(adapter.dispatch("to_date")(column, format)) }}
{% endmacro %}

{% macro duckdb__to_date(column, format) %}
    {% set strpformat = format %}
    {% set strpformat = strpformat | replace("YYYY", "%Y") %}
    {% set strpformat = strpformat | replace("MM", "%m") %}
    {% set strpformat = strpformat | replace("DD", "%d") %}

    cast(strptime(cast({{ column }} as varchar), '{{ strpformat }}') as date)
{% endmacro %}
```

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-zsh

poetry run dbt compile --profile="duckdb"
```

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```
nano definitions.py
```

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-zsh

```
class IbisResource(ConfigurableResource):
    @contextmanager
    def session(self):
        connection = ibis.duckdb.connect(...)

        try:
            yield connection
        finally:
            connection.disconnect()
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-zsh

```
defs = Definitions(
    assets=[
        john_doe_clinic_bdt_dlt_source_asset,
        *john_doe_clinic_bdt_dbt_source_table_asset_factory(),
        dbt_model_assets,
        john_doe_clinic_lab_harmonized_asset,
    ],
    resources={
        "dbt": DbtCliResource(project_dir=..., profile="duckdb"),
        "dlt": DltResource(),
        "ibis": IbisResource(),
    },
    executor=in_process_executor
)
```

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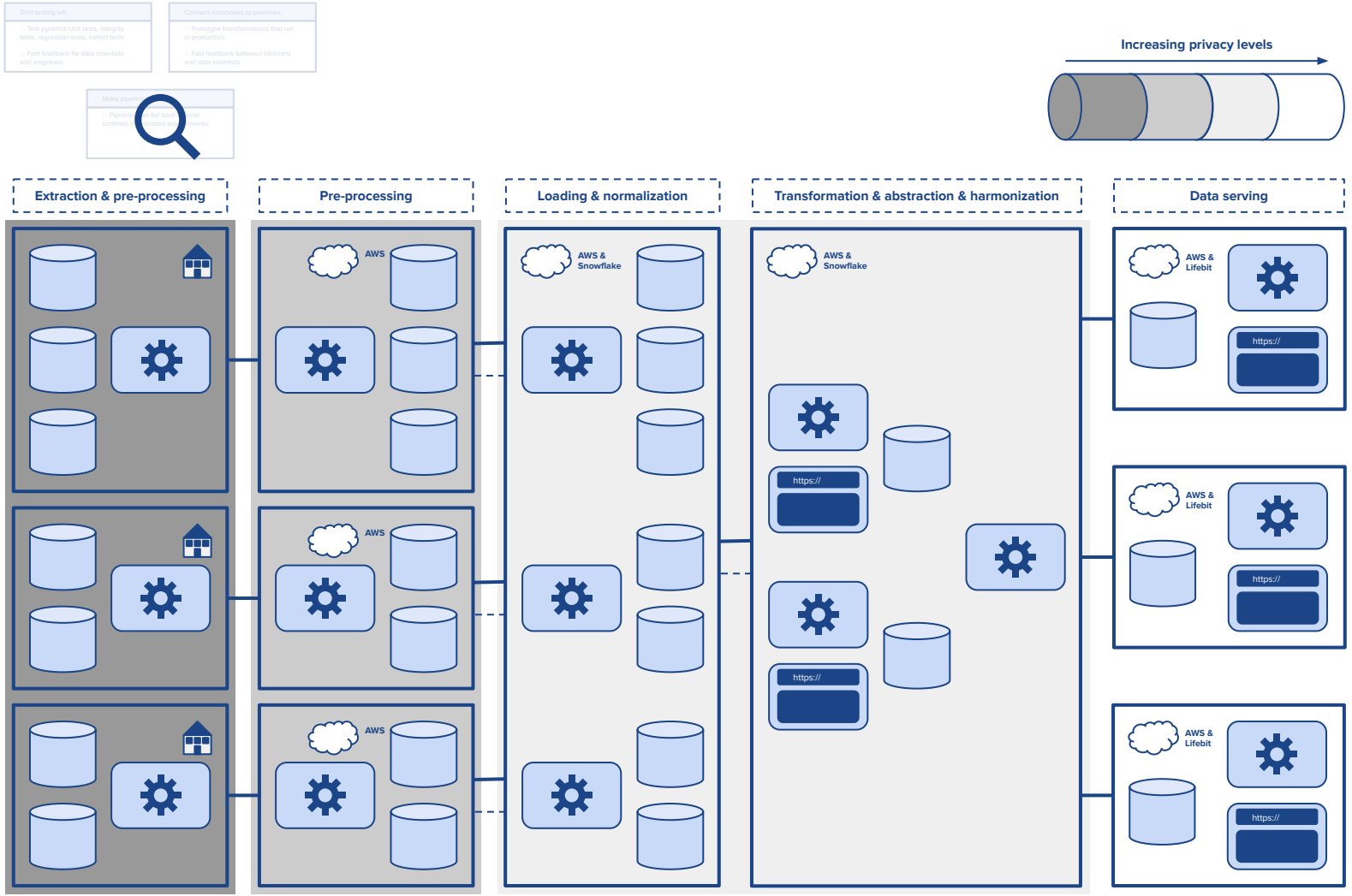

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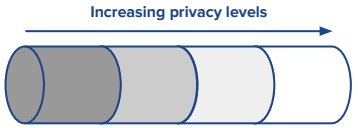

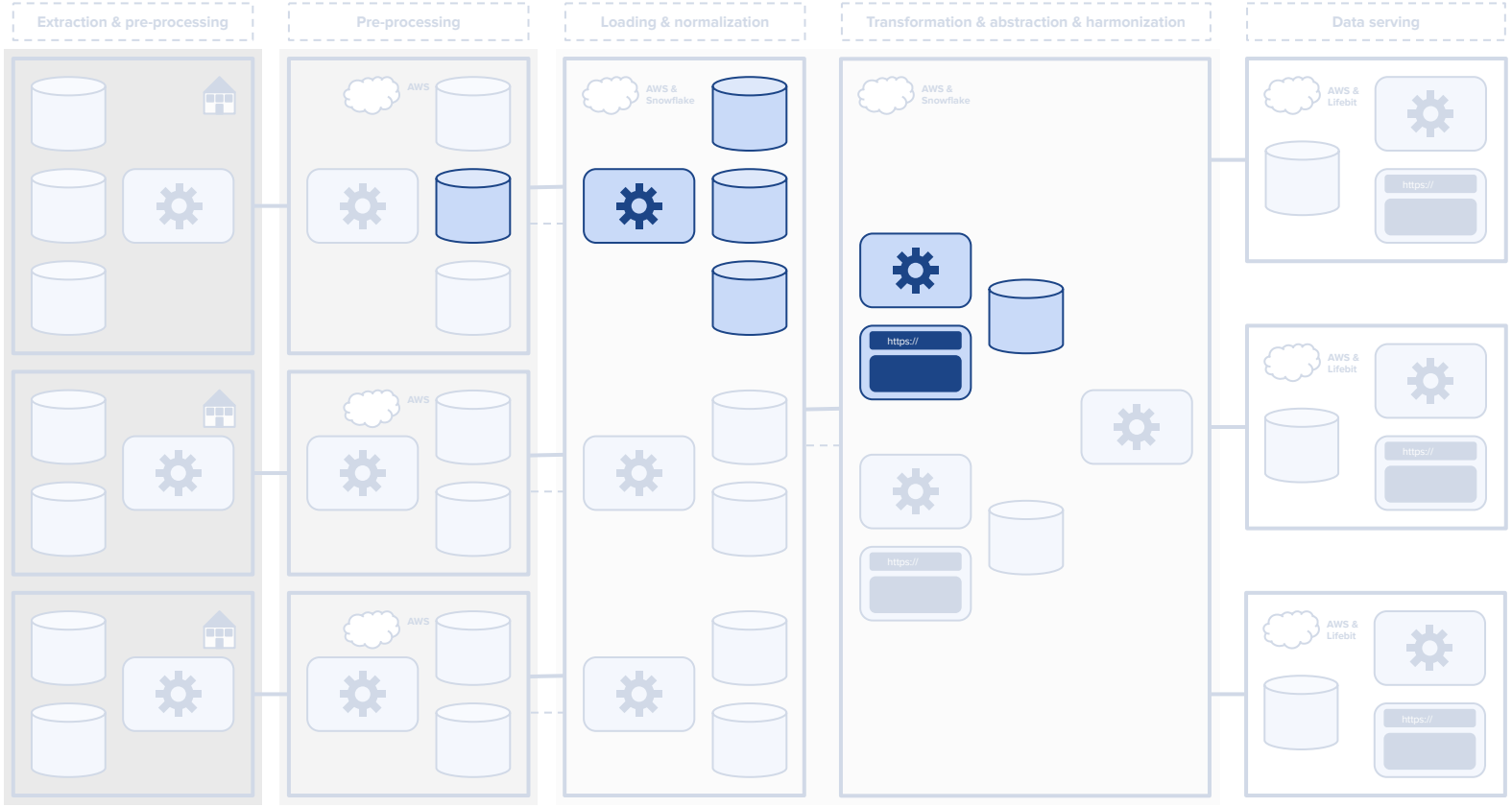

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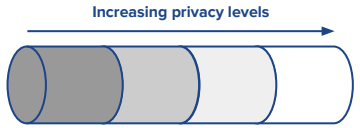

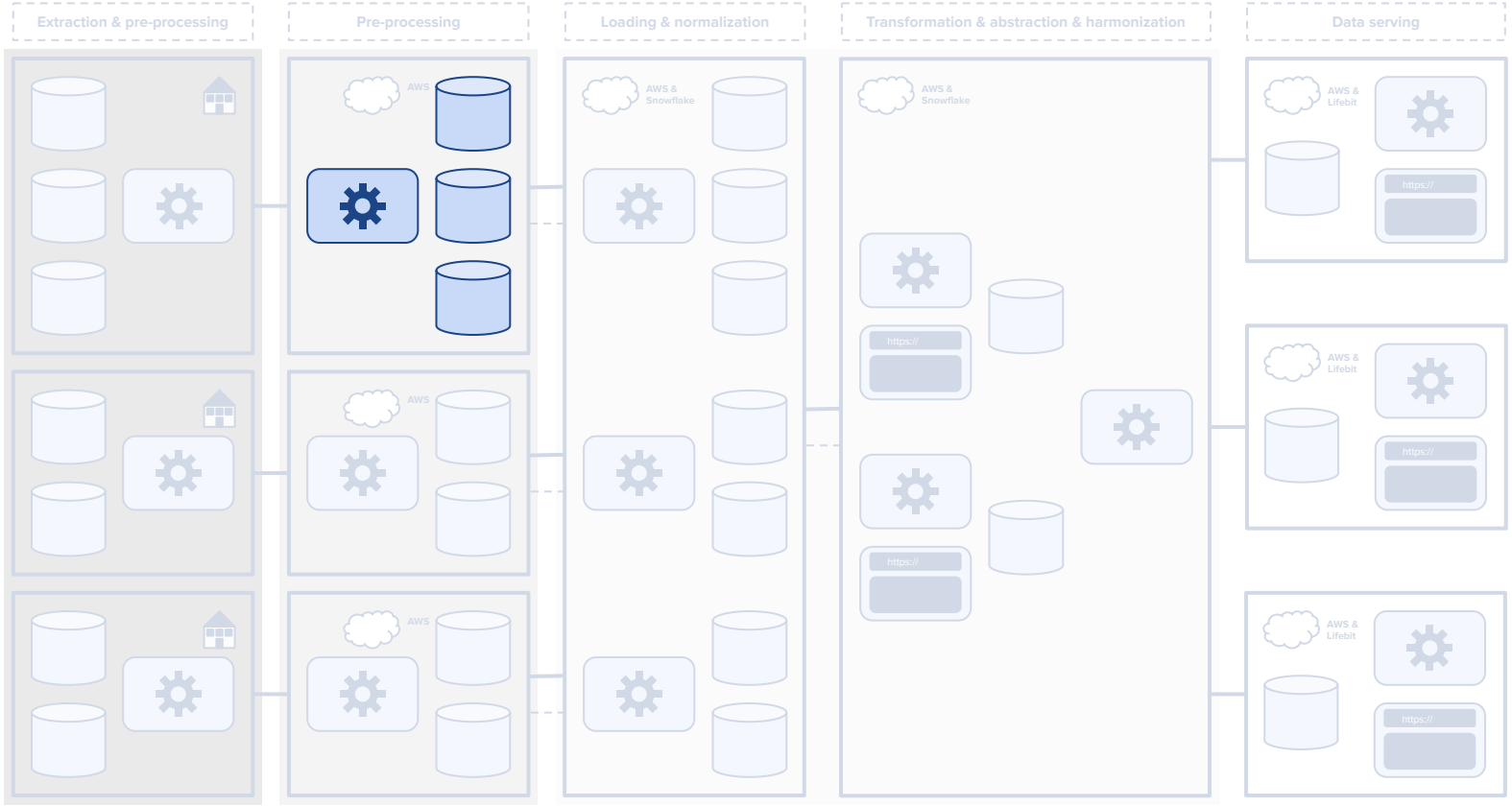

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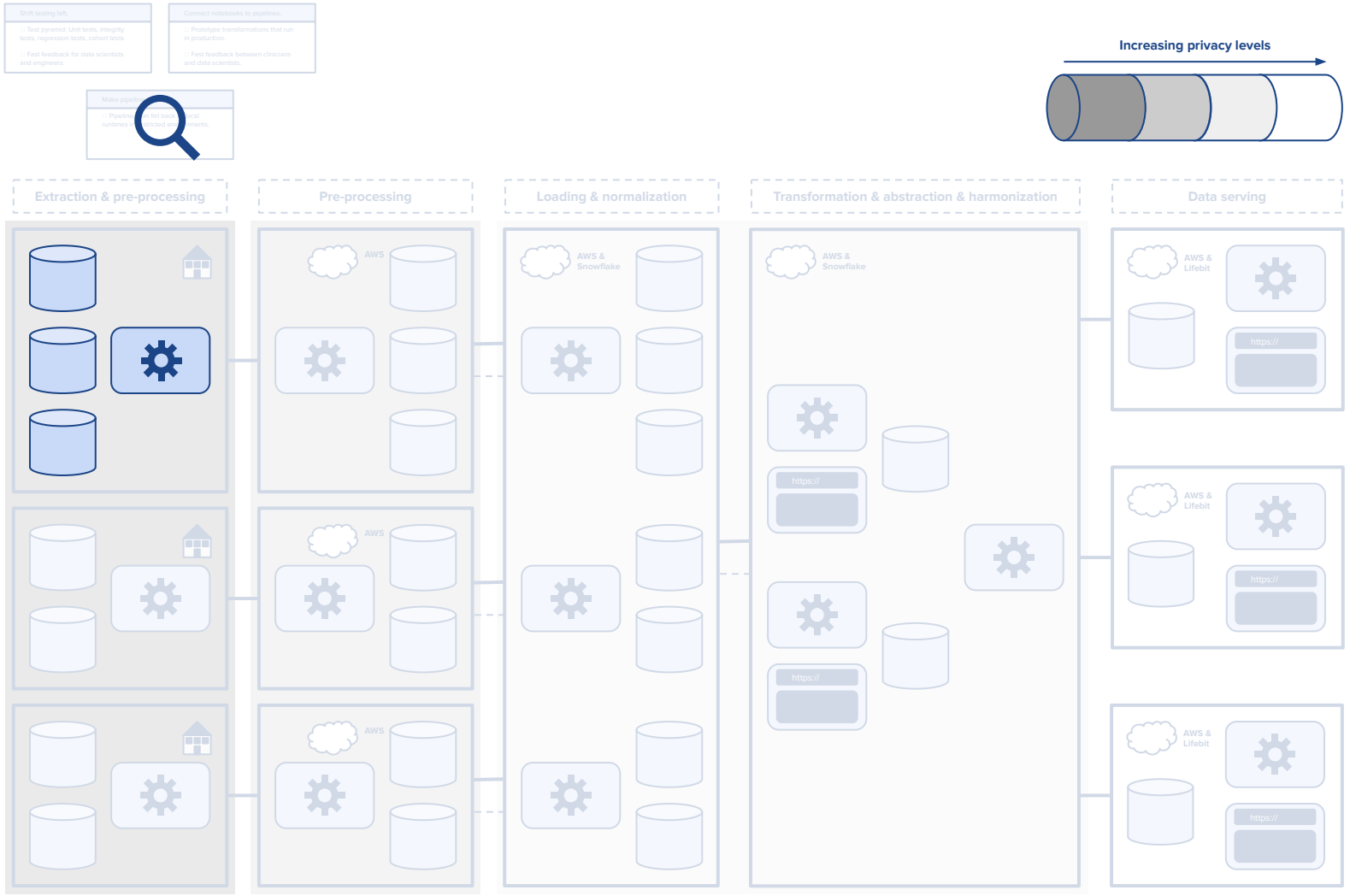

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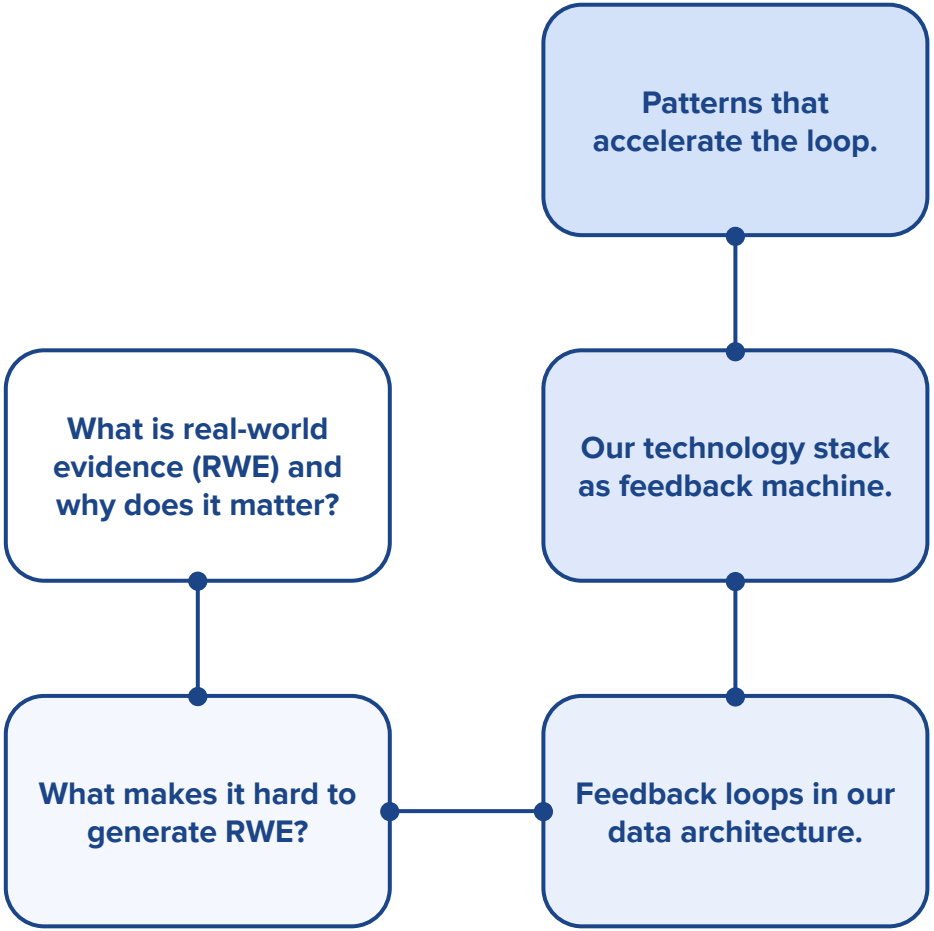

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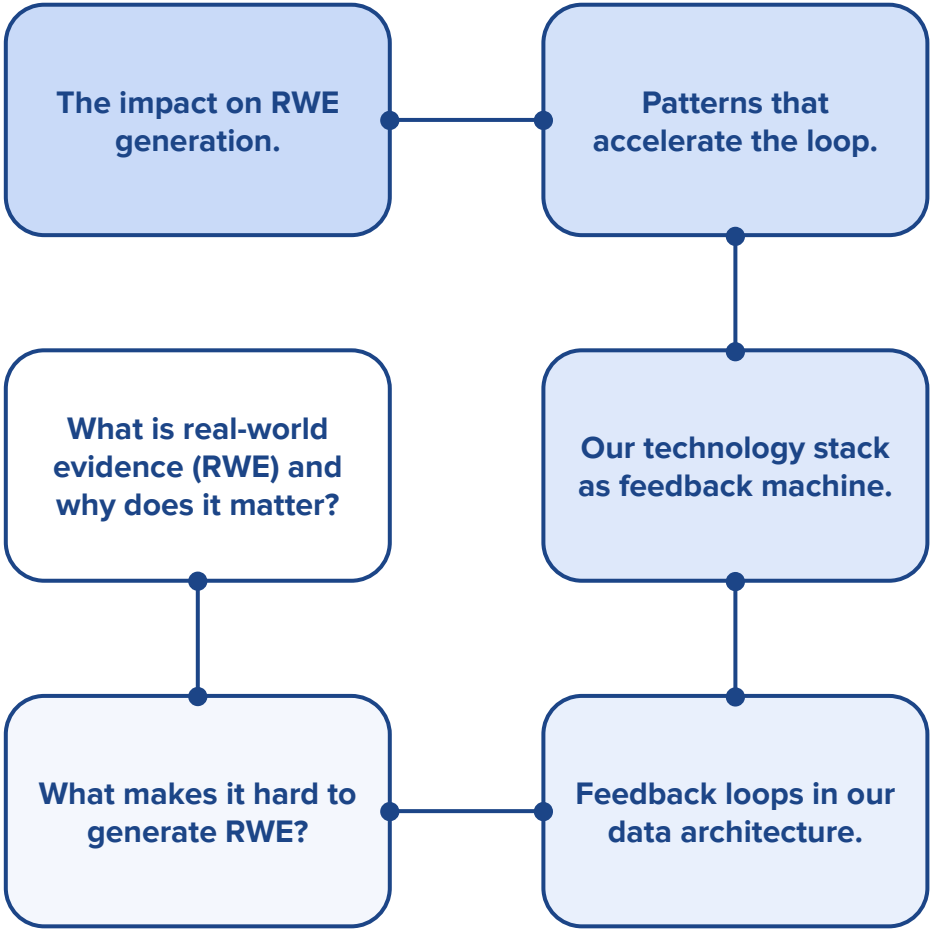

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RWE at scale

- Our data has been used in 1,200+ publications
- Research using our data has been cited 9000+ times across peer-reviewed publications
- Flatiron has published research on 25+ cancer types

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Global reach

“The methods (..) enable global researchers with the tools to investigate treatment patterns and outcomes across diverse healthcare systems, fostering high-quality, multinational evidence generation - all while working within local regulatory requirements. This work (...) [helps to] accelerate the development of therapies, improve treatment strategies, and most importantly, **benefit patients worldwide by ensuring that high-quality RWE informs clinical decisions and health policies on a global scale**.”

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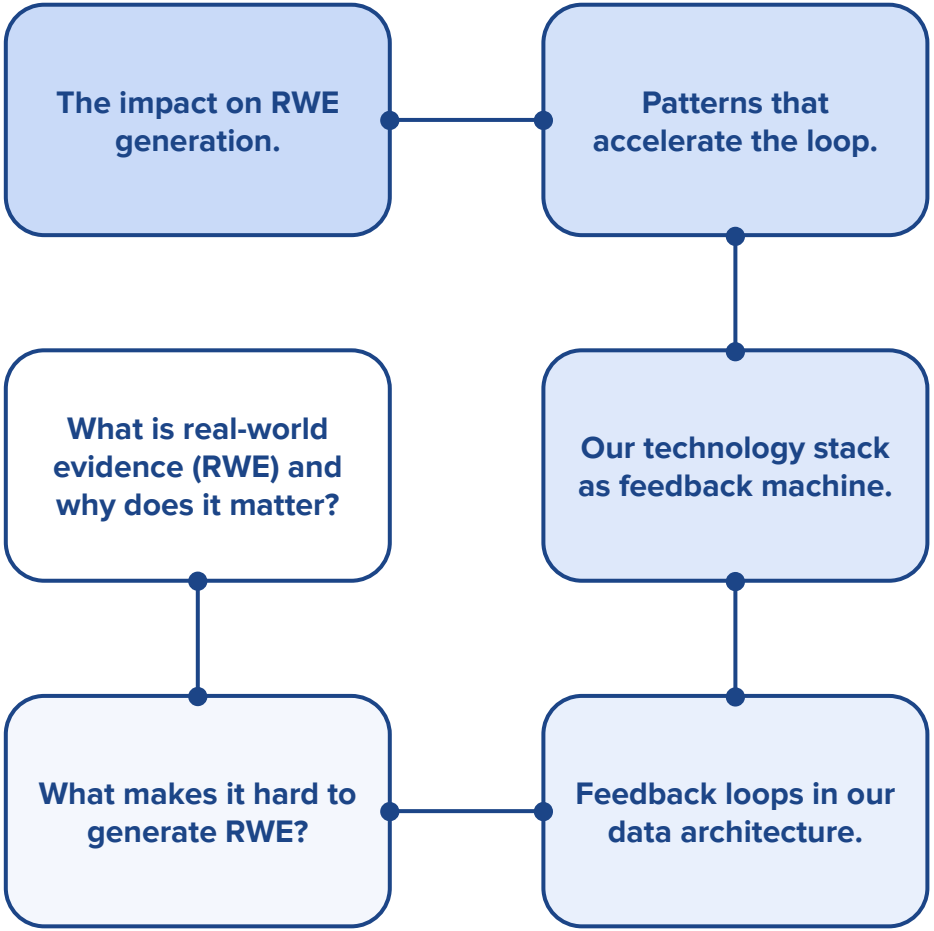

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Thank you!