Foundations of Semantic Knowledge Graphs

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RDF Serialisations

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An RDF Graph can be serialised in a number of different formats

We mainly discussed the abstract syntax of RDF.
In order to exchange RDF graphs, **concrete syntacic forms** are needed to **encode** RDF graphs.

There are numerous syntactic formats available:

- 🔍 N-Triples is a simple line-based format
- 🔍 Turtle adds convenient abbreviations to N-Triples
- JSON-LD for encoding RDF graphs in JSON
- RDF/XML for encoding RDF graphs in XML
- RDFa for embedding RDF graphs into HTML

Further historic/unofficial formats exist but are hardly relevant today.

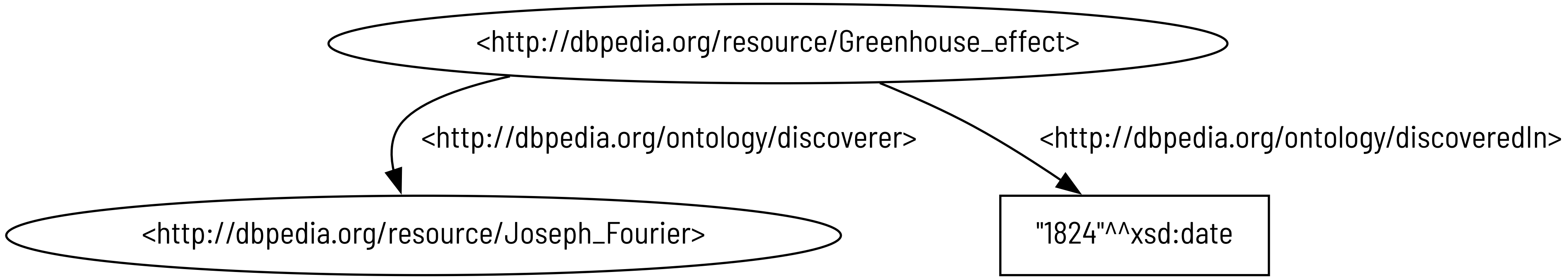
N-Triples

N-Triples is almost the simplest format conceivable:

- Each line encodes one triple:
  - IRIs are written in angle brackets, e.g., `<https://www.tu-dresden.de/>`
  - Literals are written as usual with a given type IRI, e.g., `"2019-10-22"^^<http://www.w3.org/2001/XMLSchema#date>` or with a language-tag, e.g., `"knowledge graph"@en`
  - Blank nodes are written as `_:stringId`, where `stringId` is a string that identifies the blank node within the document (it has no global meaning)
  - Parts are separated by whitespace, and lines end with .
- Unicode is supported, but various escape sequences also work
- Comments are allowed after triples (nowhere else); they start with `#`

Full specification at https://www.w3.org/TR/n-triples/

Example


<http://dbpedia.org/resource/Greenhouse_effect>
<http://dbpedia.org/ontology/discoverer>
<http://dbpedia.org/ontology/discoveredIn>
<http://dbpedia.org/resource/Joseph_Fourier>
"1824"^^xsd:date

```
<http://dbpedia.org/resource/Greenhouse_effect>
    <http://dbpedia.org/ontology/discoveredIn> "1824"^^<http://www.w3.org/2001/XMLSchema#date> .

<http://dbpedia.org/resource/Greenhouse_effect>
    <http://dbpedia.org/ontology/discoverer> <http://dbpedia.org/resource/Joseph_Fourier> .
```

N-Triples Summary

Advantages 👍

- Very simple
- Fast and easy to parse
- Processable even with basic text-processing tools, e.g., grep

Disadvantages 👎

- Somewhat inefficient in terms of storage space
- Not particularly human-friendly (reading and writing)

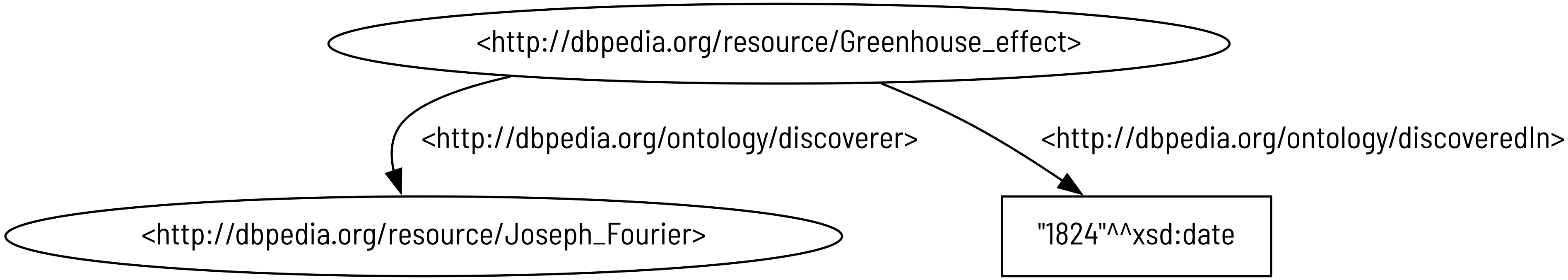
Turtle (Terse RDF Triple Language) Notation

The Turtle format **extends N-Triples** with several **convenient abbreviations**:

- Prefix declarations and base namespaces allow us to **shorten IRIs**
- If we terminate triples with `;` the next triple is assumed to start with the same subject
- If we terminate triples with `,` the next triple is assumed to start with the same subject and predicate
- **Blank nodes** can be encoded using square brackets; they might contain predicate-object pairs that refer to the blank node as subject
- More liberal support for **comments** (possibly on own line)
- Simpler forms for some kinds of **data values**

There are several other shortcuts and simplifications. Full specification at https://www.w3.org/TR/turtle/.

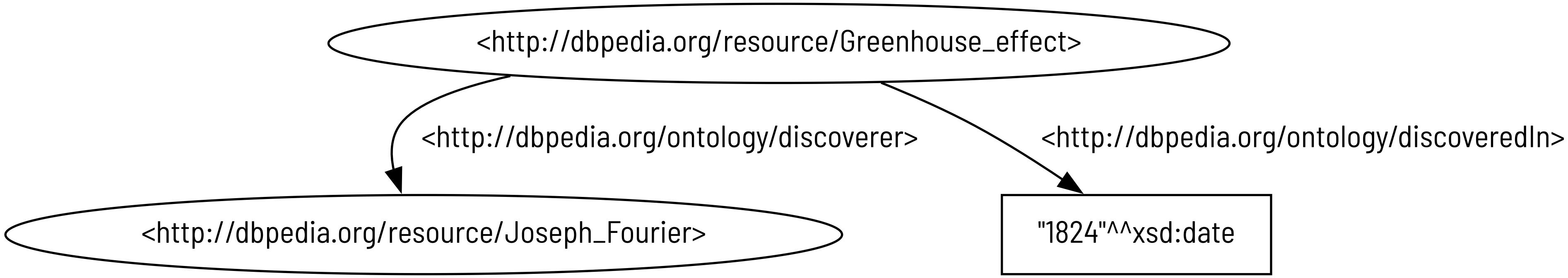
Example: Using prefixes for resources and data values and a base IRI


<http://dbpedia.org/resource/Greenhouse_effect>
<http://dbpedia.org/ontology/discoverer>
<http://dbpedia.org/ontology/discoveredIn>
<http://dbpedia.org/resource/Joseph_Fourier>
"1824"^^xsd:date

```
@prefix dbo: <http://dbpedia.org/ontology/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@base  <http://dbpedia.org/resource/> .

<Greenhouse_effect> dbo:discoveredIn "1824"^^xsd:date .

<Greenhouse_effect> dbo:discoverer <Joseph_Fourier> .
```

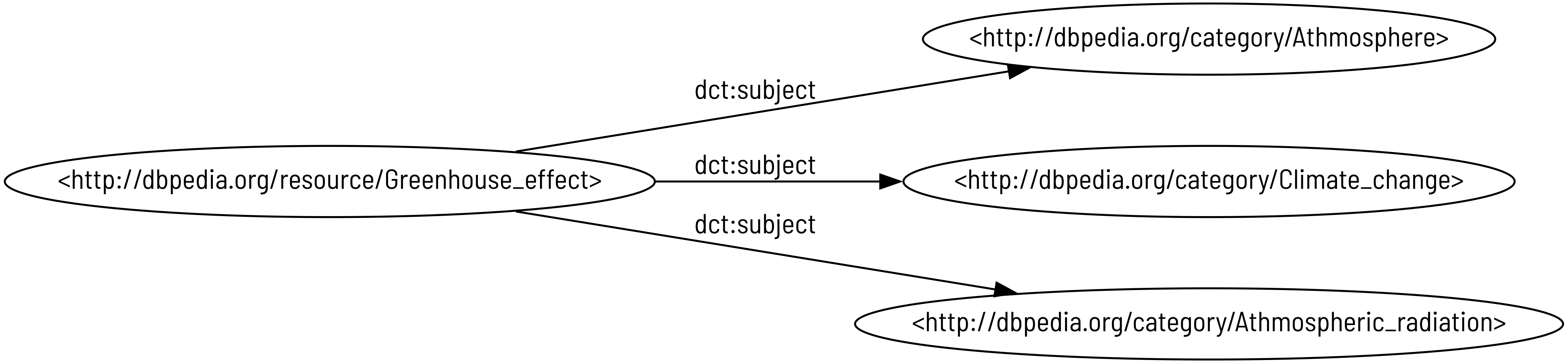
- `@base` is used to declare a base IRI, so that we can use relative IRIs
- `@prefix` is used to declare abbreviations for IRI prefixes

Turtle: Use of Semicolon by example


<http://dbpedia.org/resource/Greenhouse_effect>
<http://dbpedia.org/ontology/discoverer>
<http://dbpedia.org/ontology/discoveredIn>
<http://dbpedia.org/resource/Joseph_Fourier>
"1824"^^xsd:date

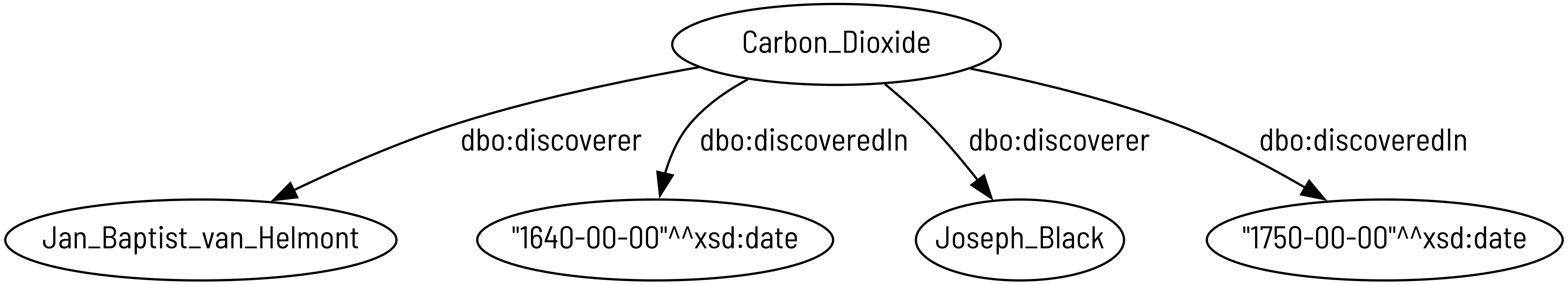
```
@prefix dbo: <http://dbpedia.org/ontology/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@base  <http://dbpedia.org/resource/> .

<Greenhouse_effect> dbo:discoveredIn "1824"^^xsd:date ;

                    dbo:discoverer <Joseph_Fourier> .
```

Turtle-Abbreviations: Use of Comma by example


<http://dbpedia.org/category/Athmosphere>
dct:subject
dct:subject
<http://dbpedia.org/resource/Greenhouse_effect>
<http://dbpedia.org/category/Climate_change>
dct:subject
<http://dbpedia.org/category/Athmospheric_radiation>

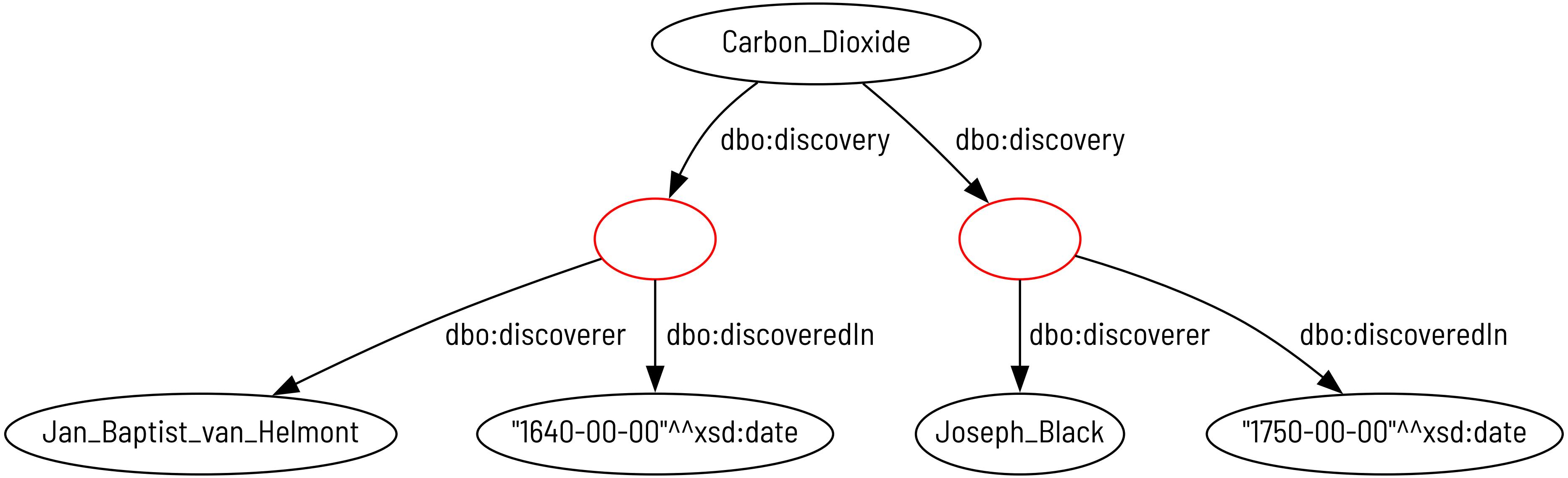
```
@prefix dct: <http://purl.org/dc/terms/> .
@prefix dbc: <http://dbpedia.org/category/> .
@base        <http://dbpedia.org/resource/> .

<Greenhouse_effect> dct:subject dbc:Athmosphere ,
                                dbc:Climate_change ,
                                dbc:Athmospheric_radiation .
```

Turtle: How to model multi-value relations



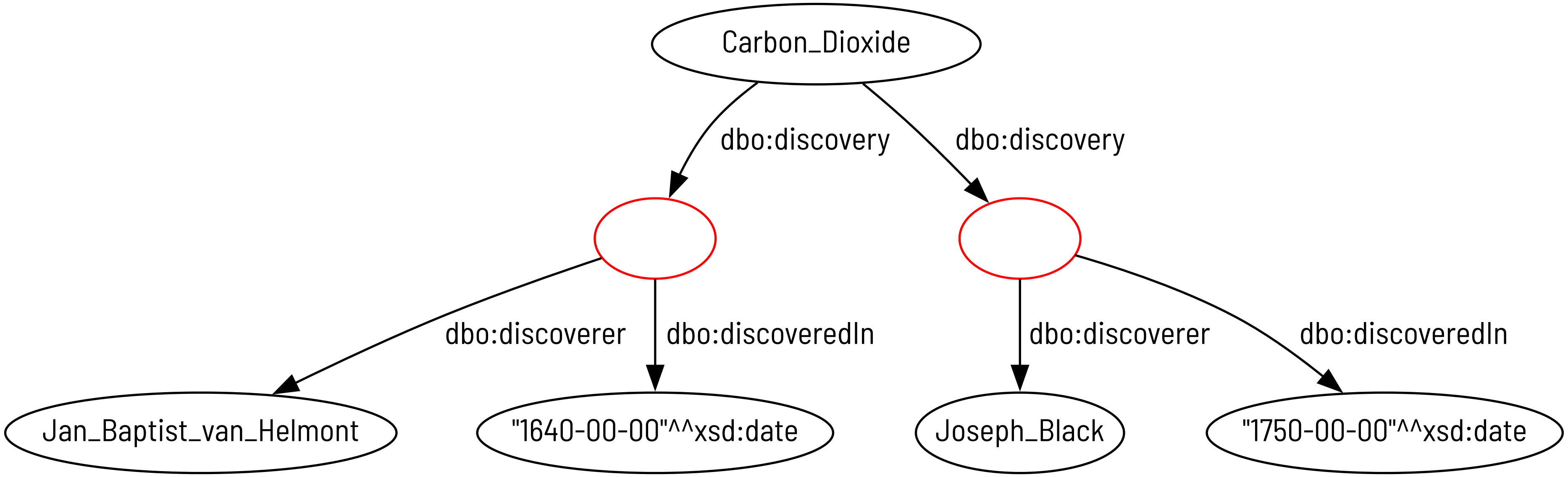
- Problem: Carbon dioxide was discovered / rediscovered by 2 scientists at different times.
- How to model this in RDF?
- Problem: unique association

Turtle: Using Blank nodes to model multi-value relations



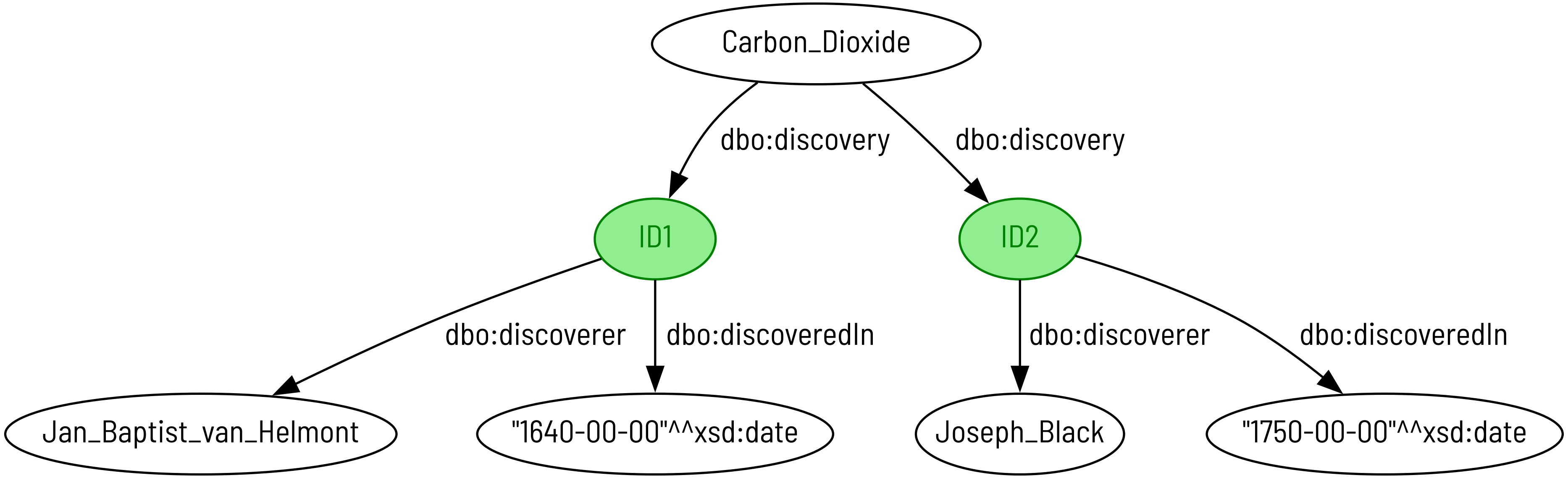
- **Multi-Valued Relations**
  - Blank Nodes (Bnodes) can be introduced to represent multi-valued relationships.
  - Blank Nodes can be introduced for resources that don't need a name (auxiliary nodes).

Turtle: Serialising anonymous blank nodes



```
@prefix dbo: <http://dbpedia.org/ontology/> .
@prefix xsd: <http://www.w3c.org/2001/XMLSchema#> .
@base <http://dbpedia.org/resource/> .

<Carbon_Dioxide> dbo:discovery [ dbo:discoverer <Jean_Baptist_van_Helmont> ;
                                 dbo:discoveredIn "1640-00-00"^^xsd:date
                               ],
                               [ dbo:discoverer <Joseph_Black> ;
                                 dbo:discoveredIn "1750-00-00"^^xsd:date
                               ].
```

Turtle: Serialising locally identifyable blank nodes



```
@prefix dbo: <http://dbpedia.org/ontology/>. @prefix xsd: <http://www.w3c.org/2001/XMLSchema#>. @base <http://dbpedia.org/resource/>.

<Carbon_Dioxide> dbo:discovery _:ID1, _:ID2 .  //dereferenceable blank nodes can only be referenced from inside a document / graph

_:ID1 dbo:discoverer <Jan_Baptist_van_Helmont> ;
      dbo:discoveredIn "1640-00-00"^^xsd:date .

_:ID2 dbo:discoverer <John_Black> ;
      dbo:discoveredIn "1750-00-00"^^xsd:date .
```

Turtle Summary

Advantages 👍

- Still quite simple
- Not hard to parse
- Human-readable (if formatted carefully)

Disadvantages 👎

- Not safely processable with grep and similar tools

Other Syntacic Formats

There are various further syntactic forms:

- RDF/XML
  - An XML-based encoding; historically important in RDF 1.0;
  - hard-to-parse but unable to encode all RDF graphs;
  - not human-readable either
- JSON-LD
  - A JSON-based encoding and away of specifying how existing JSON maps to RDF;
  - can re-use fast JSON parsers (esp. those in browsers)
- RDFa
  - An HTML embedding of RDF triples;
  - used for HTML document annotations (e.g., with schema.org);
  - mostly for consumption by Web crawlers

Remarks: Details about those alternative syntactic forms can be found online; we will not cover them in this modul.

Common namespaces/prefixes

Many syntactic encodings of RDF support some abbreviation mechanism for IRIs by declaring some form of namespaces or prefixes.

While prefixes can usually be declared freely, there are some standard prefixes that are conventionally used and virtually always declared in the same way. They include:

Abbr.	Abbreviated IRI prefix	Usage
xsd:	http://www.w3.org/2001/XMLSchema#	XML Schema datatypes
rdf:	http://www.w3.org/1999/02/22-rdf-syntax-ns#	RDF Vocabulary
rdfs:	http://www.w3.org/2000/01/rdf-schema#	RDF Schema: extended RDF Language

Convention: We will henceforth assume that these abbreviations are used with the above meaning throughout this course.

Abbreviations such as `xsd:dateTime` are sometimes called qualified names (qnames)

RDF Datasets

RDF 1.1 also supports datasets that consist of several graphs:

- This is useful for organising RDF data, especially within databases
- Several named graphs are identified by IRIs; there is also one default graph without any IRI
- RDF dataset = RDF data that may have more than one graph

Only some specialised syntactic forms can serialise RDF datasets with named graphs:

- N-Quads: Extension of N-Triples with optional fourth component in each line to denote graph.
- TriG: Extension of Turtle with a new feature to declare graphs (group triples of one graph in braces, with the graph IRI written before the opening brace)
- JSON-LD: Can also encode named graph

The semantics of named graphs was left open by the Working Group. Are all graphs' triples asserted to hold, or just those in the default graph? Do the IRIs of graphs denote the resource that is the set of triples given, or something else? ⇝ currently application-dependent

Summary

- RDF allows for expressing simple facts
  - Anne is the mother or Merula
- It is desirable to express more generic knowledge
  - Mothers are female
  - If somebody has a daughter, this person is a parent
- Such kind of knowledge is called **schema knowledge** or **terminological knowledge**
- **RDF Schema** allows for schema knowledge modeling (although with less expressivity than OWL)