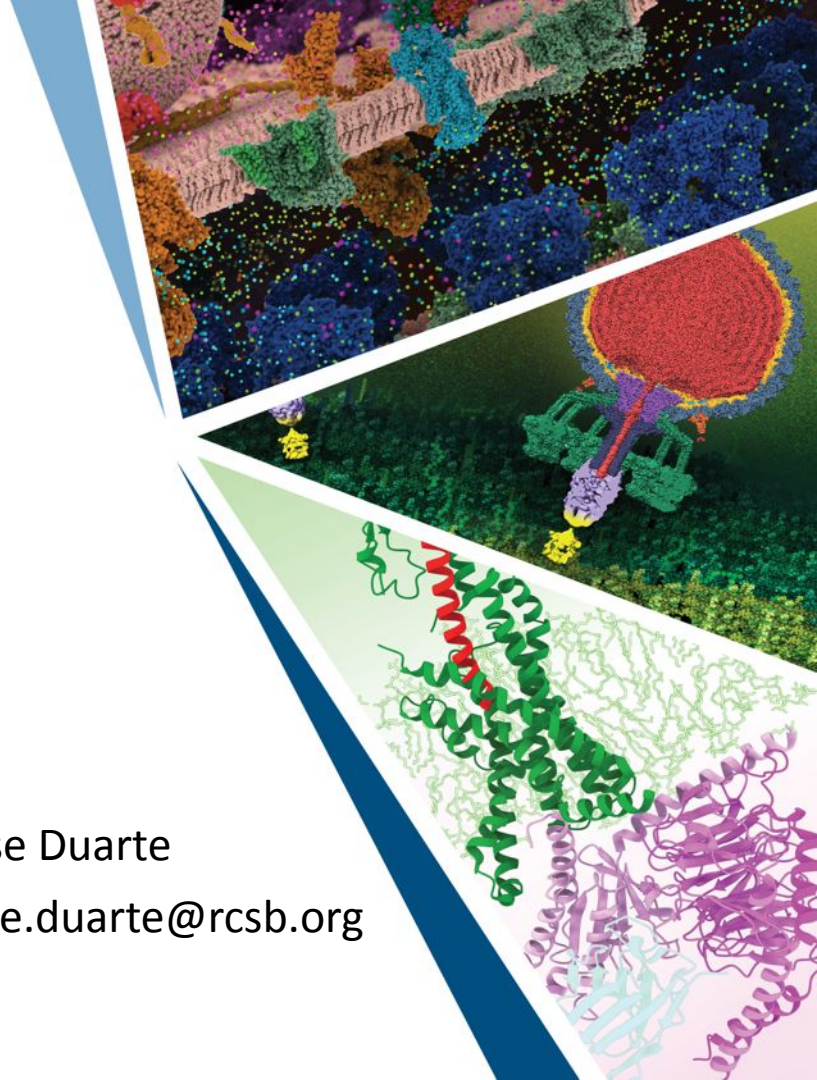
RCSB PDB
PROTEIN DATA BANK

RCSB.org

info@rcsb.org



Welcome

Leveraging RCSB PDB APIs for Bioinformatics Analyses and Machine Learning

Oct 12th, 2023

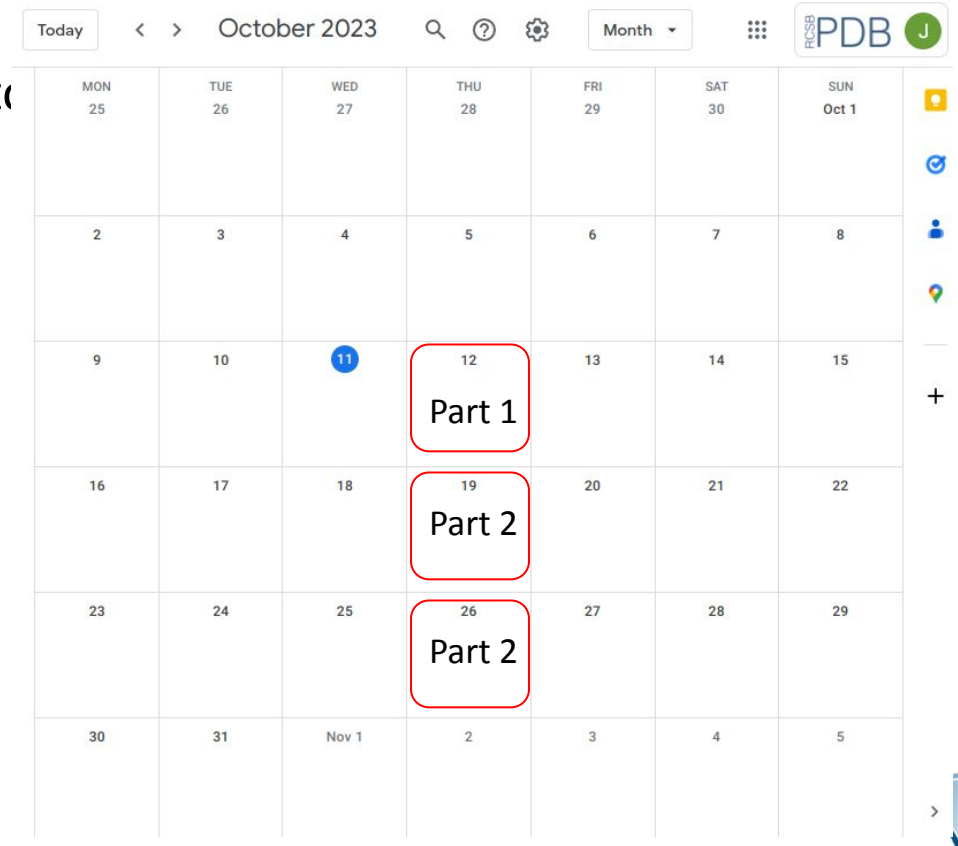
Jose Duarte

jose.duarte@rcsb.org

Course split into 2 parts

- Part 1 (today): introduction t
  APIs

- Part 2: hands-on exercise
  - Oct 19: starting 16:00 UTC
  - Oct 27: starting 00:00 UTC



Crash course recording and presentations

- Zoom recording will be posted on RCSB PDB's YouTube Channel
- Presentations will be available to participants via Exit Survey
- Q&A Summary: go.rutgers.edu/86q3uya7
- Part 2 (hands-on) registration will be shared with today's participants

Tutors

Jose Duarte

Brinda Vallat

Yana Rose

Dennis Piehl

Sebastian Bittrich

Joan Segura

Part 1 Agenda

9:00 - 9:10 AM PDT 12:00 - 12:10 PM EDT	Welcome	
9:10 - 9:40 AM PDT 12:10 - 12:40 PM EDT	Introduction to RCSB PDB APIs and data schemas	Brinda Vallat, PhD
9:40 - 10:10 AM PDT 12:40 - 1:10 PM EDT	Data API	Jose Duarte, PhD
10:10 - 10:20 AM PDT 1:10 - 1:20 PM EDT	Break	
10:20 - 10:50 AM PDT 1:20 - 1:50 PM EDT	Search API	Yana Rose, PhD
10:50 - 11:00 AM PDT 1:50 - 2:00 PM EDT	Search and Data API hands-on teaser	Dennis Piehl, PhD

Part 2 Agenda

9:00 - 9:10 AM PDT 12:00 - 12:10 PM EDT	Introduction	Dennis Piehl, PhD
9:10 - 9:40 AM PDT 12:10 - 12:40 PM EDT	Walk through a worked example in Colab	Joan Segura, PhD Sebastian Bittrich, PhD
9:40 - 10:30 AM PDT 12:40 - 1:30 PM EDT	Time for participants to work on their own problem	Tutors available for questions and breakout discussions as needed
10:30 - 11:20 AM PDT 1:30 - 2:20 PM EDT	Present results (report out). More time for Q&A	
11:20 - 11:30 AM PDT 2:20 - 2:30 PM EDT	Closing remarks	

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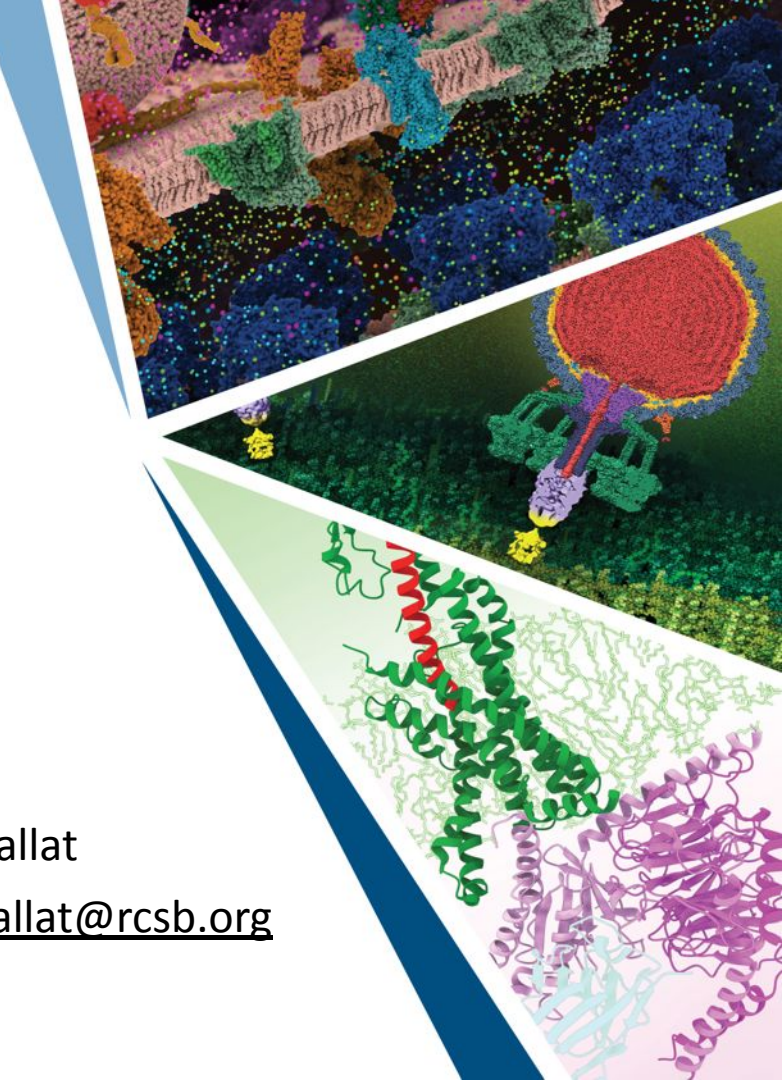


Introduction to RCSB PDB APIs and Data Schema

Leveraging RCSB PDB APIs for Bioinformatics Analyses and Machine Learning

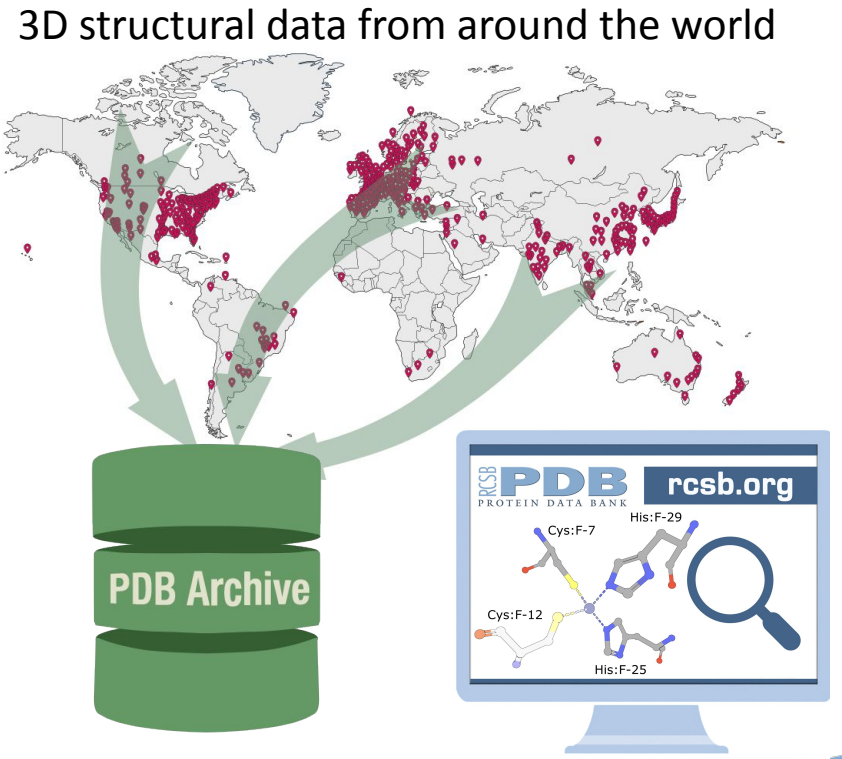
October 12th, 2023

Brinda Vallat

brinda.vallat@rcsb.org

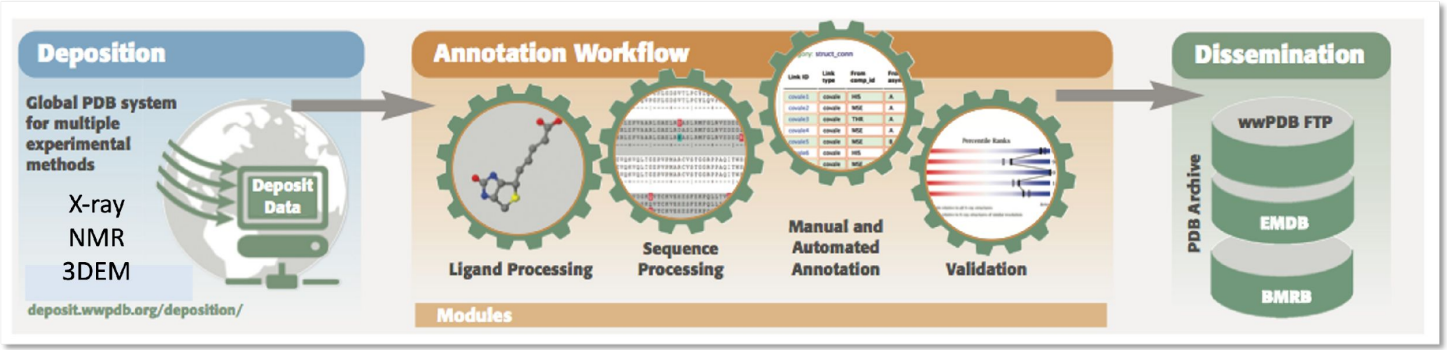
The RCSB PDB Web Portal (RCSB.org)

- **RCSB.org:** Tools for searching, accessing, visualizing, analyzing, and downloading the contents of the PDB Archive
- Open access to >210,000 experimental structures of macromolecules
- >1 million Computed Structure Models (CSMs) predicted using AI/ML methods
- Living data resource integrated with annotations from ~50 external biodata resources (UniProt, SCOPe, CATH, …)
- **PDB-101 (pdb101.rcsb.org):** Educational resources and training

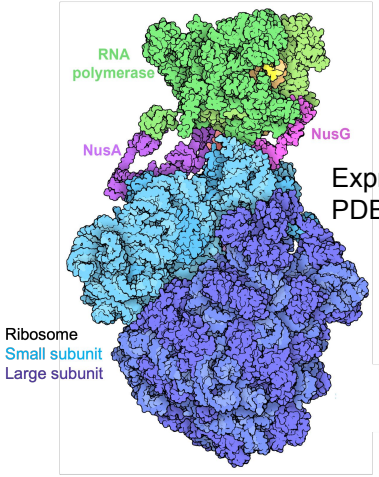


RCSB Protein Data Bank (2022) *Protein Science* **31**, 187–208.

Data in the PDB Archive



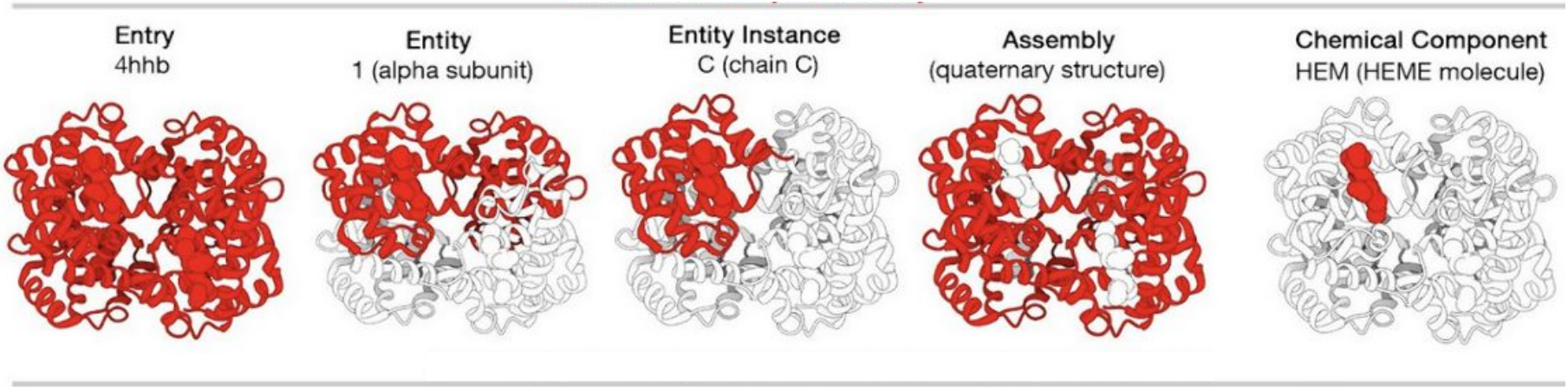
- Experimentally determined structures of macromolecules and their complexes
  - Atomic coordinates
  - Molecular descriptions, references
  - Source organisms, details about sample, experiment
  - Citation, software, authors
- Depositor provided and software generated
- Well-curated data ensures data standardization and completeness
- Validation metrics for assessment of structure quality



Expressome
PDB 6x9q

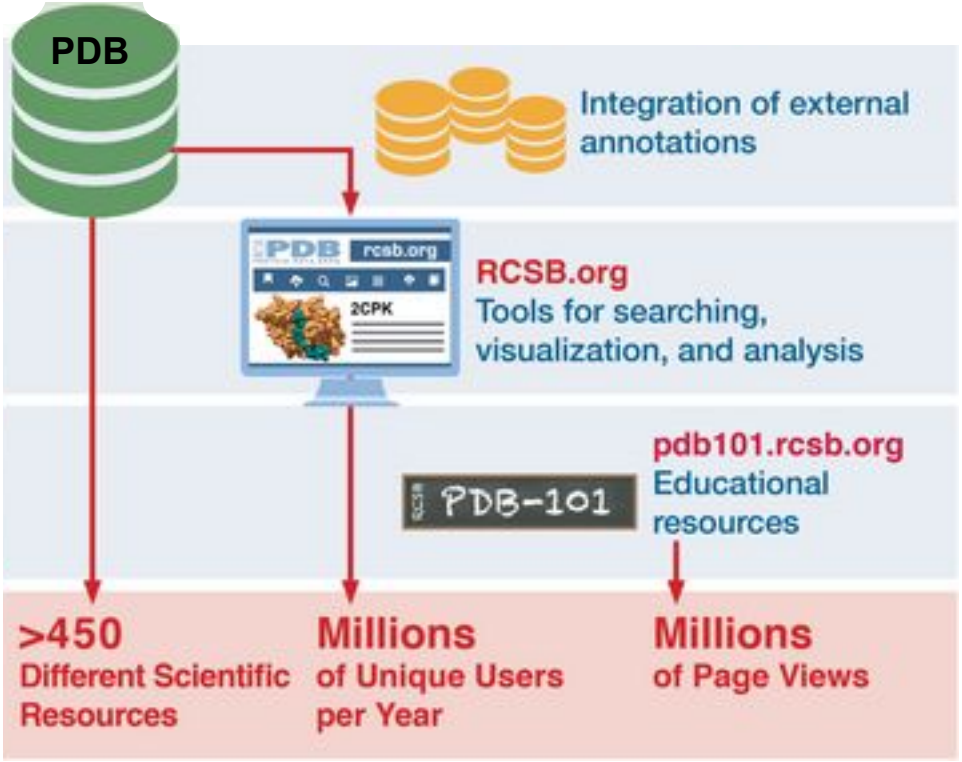
https://pdb101.rcsb.org/motm/253

PDB Data Organization: Molecular Hierarchy



https://data.rcsb.org/index.html#data-organization
https://pdb101.rcsb.org/learn/guide-to-understanding-pdb-data/introduction-to-rcsb-pdb-apis

RCSB.org: Integration of External Annotations



RCSB Protein Data Bank (2022) *Protein Science* **31**, 187–208

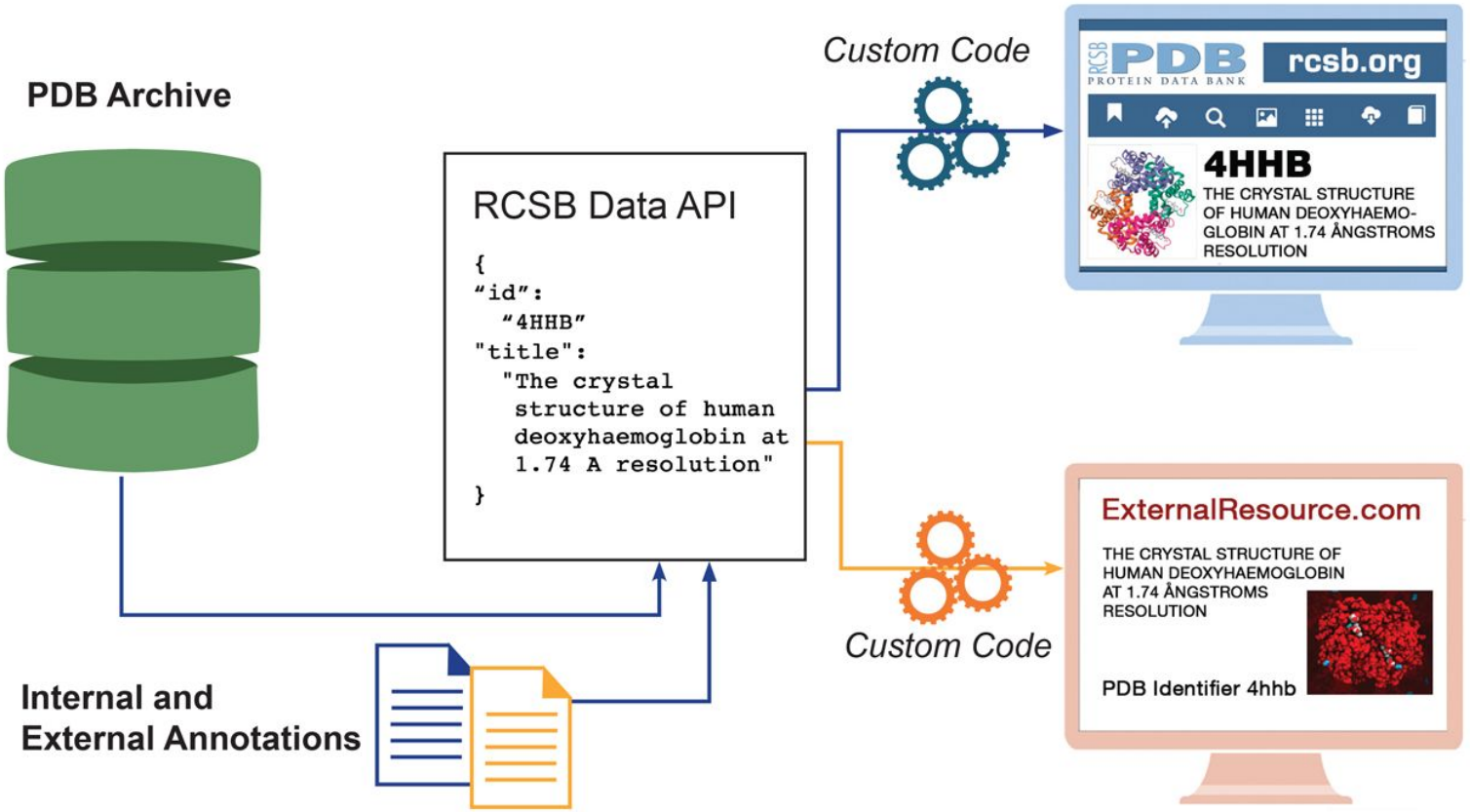
RCSB.org: Information Integrated from External Resources

Data Content Type	Resource Name
Protein domain classification	SCOP2, CATH
Evolution related	ECOD
Antibiotic resistance	CARD
Immunology related	IMGT, SAbDab
Small molecule related	CSD, COD, ChEBI, ChEMBL, NCBI PubChem
Glycan correspondences	Glygen, GlyToucan, GlyCosmos
Membrane protein related	MemProtMD, PDBTM, OPM, mpstruc
Diffraction images	SBGrid, proteindiffraction.org

Data Content Type	Resource Name
Gene and Taxonomy	NCBI Gene and Taxonomy, Gencode
Molecular function, Cellular component, Biological processes	GO
Drug target related	Pharos, Drugbank
Enzyme nomenclature	ExploreEnZ
Binding affinities	BindingDB, Binding MOAD
Protein families	Pfam, InterPro
Citation and literature	Pubmed, PMC
Sequence related	UniProt

https://www.rcsb.org/docs/general-help/data-from-external-resources-integrated-into-rcsb-pdb

RCSB.org: Powered by APIs



https://pdb101.rcsb.org/learn/guide-to-understanding-pdb-data/introduction-to-rcsb-pdb-apis

RCSB.org APIs

Application Programming Interface or APIs provide programmatic access to data available from RCSB.org

Two main APIs that power the RCSB.org website are:

- **Data API** serves to retrieve data when the PDB identifiers are known
- **Search API** serves to find out what identifiers match specific search conditions

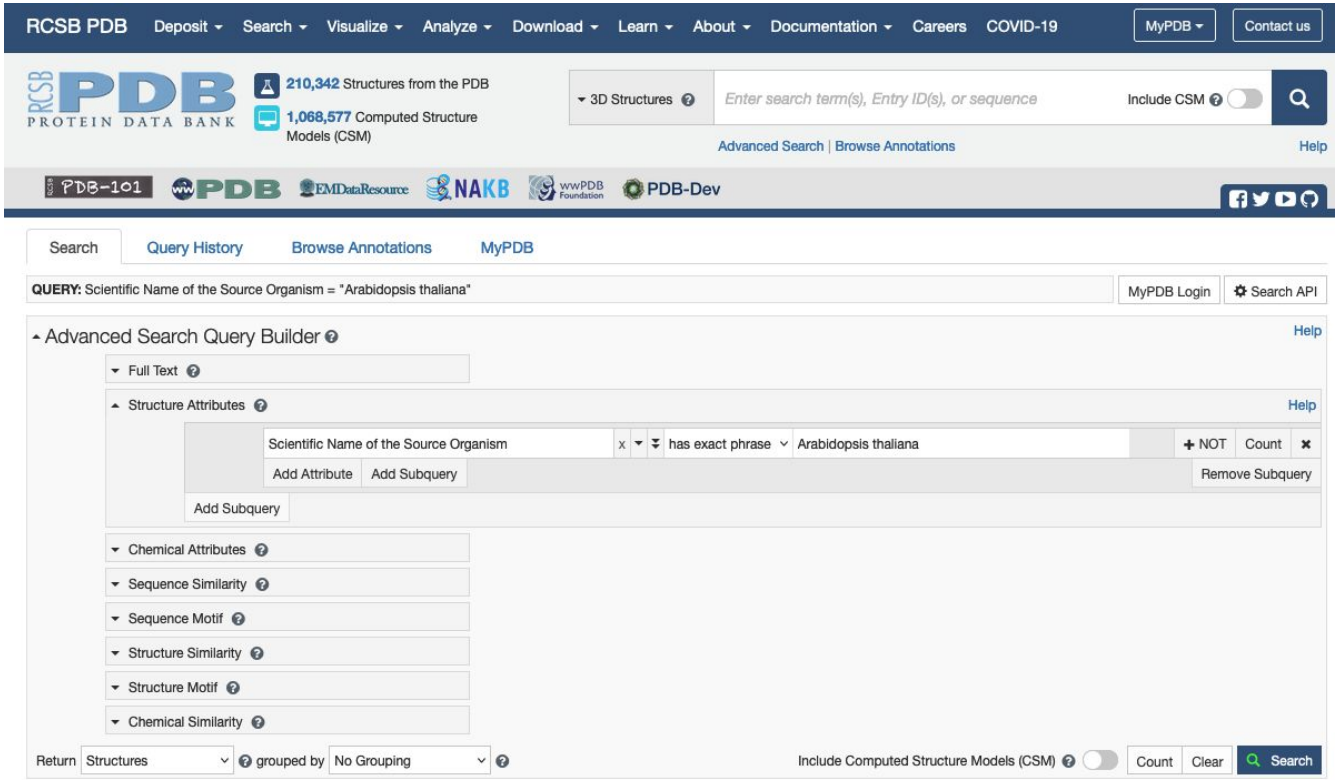
https://www.rcsb.org/docs/programmatic-access/web-services-overview

RCSB.org: Other APIs

- **ModelServer** is a service for accessing subsets of macromolecular model data. It delivers atomic coordinates together with annotations in a compressed BinaryCIF encoding (BCIF).
- **VolumeServer** is a service for accessing subsets of volumetric data and provides near-instant access to large data sets.
- **1D Coordinate Server** compiles alignments between structural and sequence databases and integrates protein positional features from multiple resources. Alignments are available for *Refseq*, *UniProt*, and *PDB* sequences.

https://www.rcsb.org/docs/programmatic-access/web-services-overview

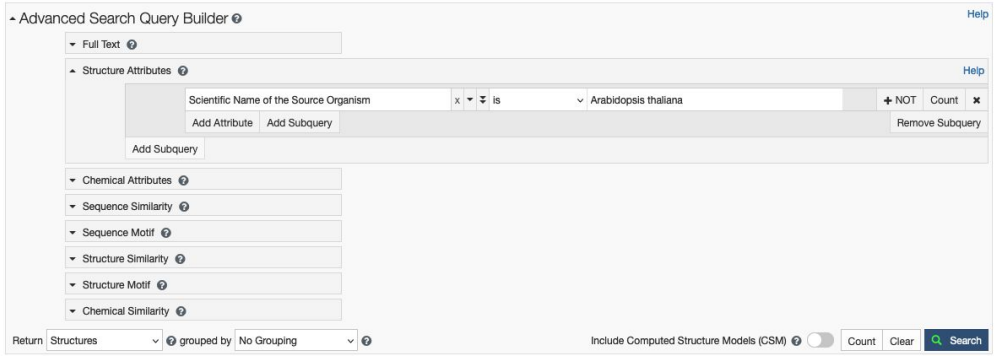
Search Tools at RCSB.org



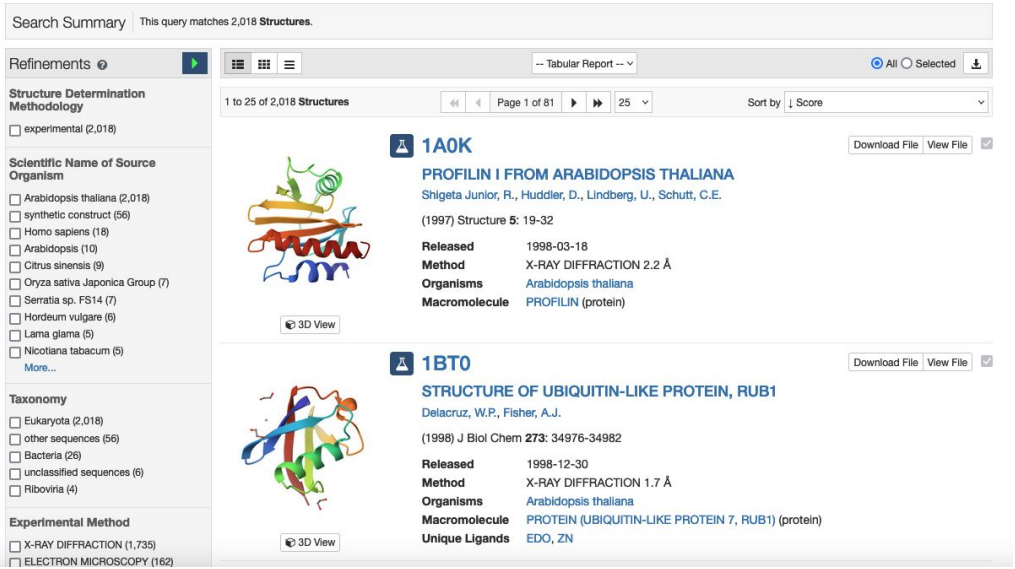
← Basic search

Advanced search

RCSB.org: Search Results Page



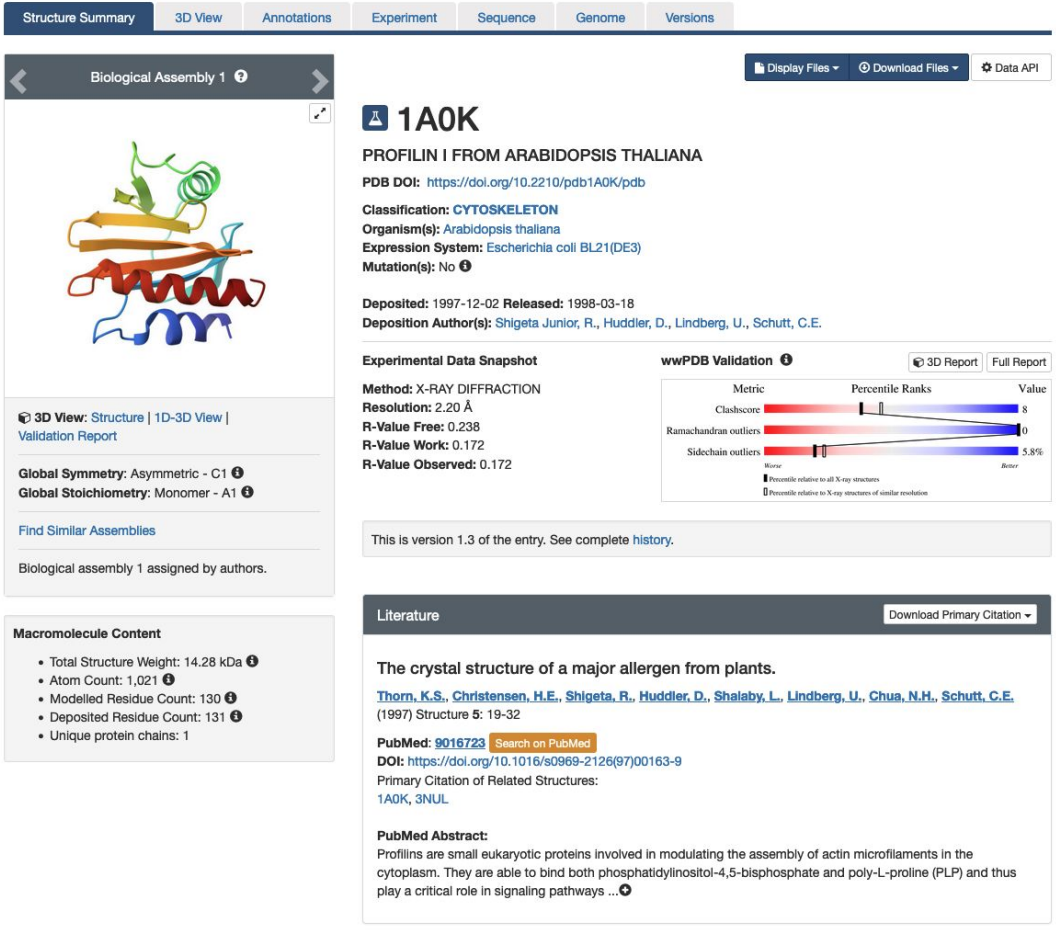
← Structure attribute search



Search Results

- Search API retrieves the identifiers matching the search criteria
- Data API fetches data related to the identifiers (Title, Authors, Publication, Release date, Experimental method, Macromolecule name)

RCSB.org: Structure Summary Page



Data API provides information seen on the “Structure Summary” page

RCSB.org: Experiment Details

Structure Summary | 3D View | Annotations | **Experiment** | Sequence | Genome | Versions

Display Files | Download Files | Data API

1A0K

PROFILIN I FROM ARABIDOPSIS THALIANA

X-RAY DIFFRACTION

Crystallization

Crystalization Experiments				
ID	**Method**	**pH**	**Temperature**	**Details**
1		5		2.0 M AMMONIUM SULFATE, 0.1 M CITRATE PH 5.0, 10 MM DTT, 0.2 MM EDTA

Crystal Properties	
Matthews coefficient	**Solvent content**
1.9	22

Crystal Data

Unit Cell	
Length (Å)	**Angle (°)**
a = 43.05	α = 90
b = 43.53	β = 90
c = 59.87	γ = 90

Symmetry	
Space Group	P 21 21 21

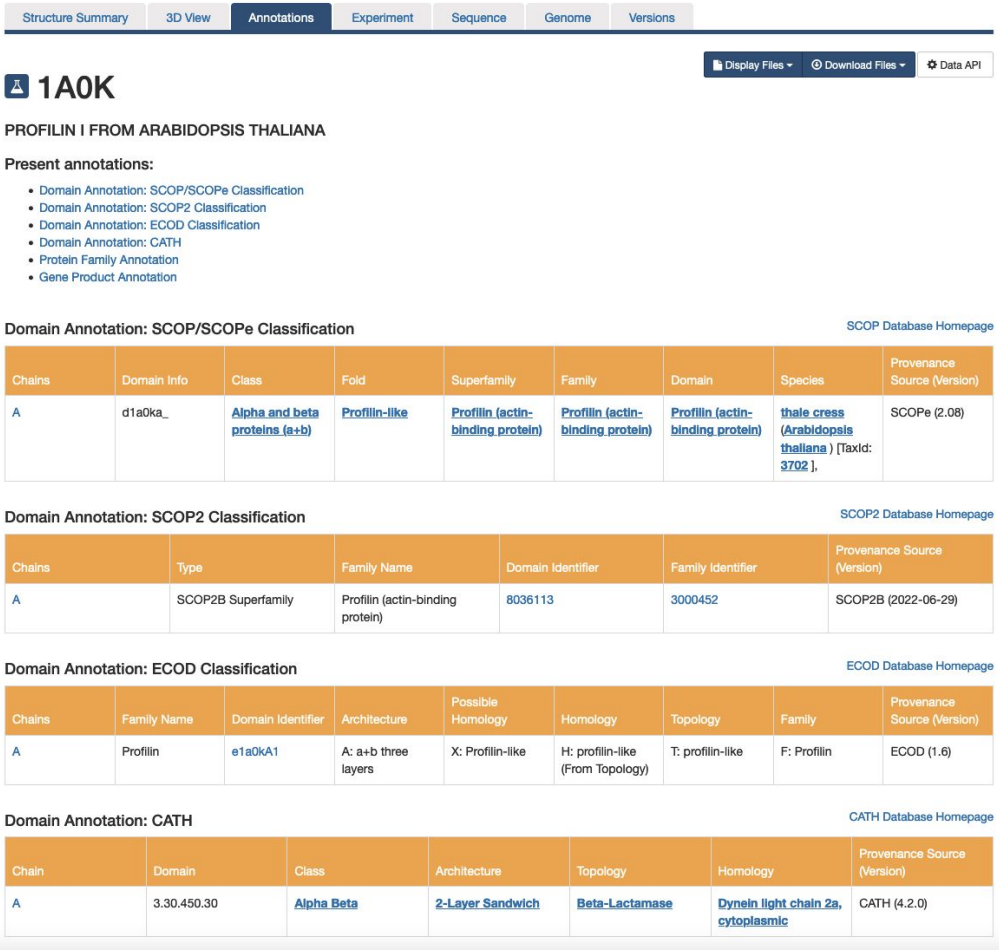
Diffraction

Diffraction Experiment									
ID #	**Crystal ID**	**Scattering Type**	**Data Collection Temperature**	**Detector**	**Detector Type**	**Details**	**Collection Date**	**Monochromator**	**Protocol**
1	1	x-ray	298	IMAGE PLATE	RIGAKU	YALE MIRRORS	1996-09-29	M	

Radiation Source					
ID #	**Source**	**Type**	**Wavelength List**	**Synchrotron Site**	**Beamline**
1	ROTATING ANODE	RIGAKU			

Data API provides information seen on the “Experiment” tab

RCSB.org: External Annotations



Structure Summary | 3D View | Annotations | Experiment | Sequence | Genome | Versions

Display Files | Download Files | Data API

1A0K

PROFILIN I FROM ARABIDOPSIS THALIANA

Present annotations:

- Domain Annotation: SCOP/SCOPe Classification
- Domain Annotation: SCOP2 Classification
- Domain Annotation: ECOD Classification
- Domain Annotation: CATH
- Protein Family Annotation
- Gene Product Annotation

Domain Annotation: SCOP/SCOPe Classification

SCOP Database Homepage

Chains	Domain Info	Class	Fold	Superfamily	Family	Domain	Species	Provenance Source (Version)
A	d1a0ka_	Alpha and beta proteins (a+b)	Profilin-like	Profilin (actin-binding protein)	Profilin (actin-binding protein)	Profilin (actin-binding protein)	thale cress (Arabidopsis thaliana) [TaxId: 3702],	SCOPe (2.08)

Domain Annotation: SCOP2 Classification

SCOP2 Database Homepage

Chains	Type	Family Name	Domain Identifier	Family Identifier	Provenance Source (Version)
A	SCOP2B Superfamily	Profilin (actin-binding protein)	8036113	3000452	SCOP2B (2022-06-29)

Domain Annotation: ECOD Classification

ECOD Database Homepage

Chains	Family Name	Domain Identifier	Architecture	Possible Homology	Homology	Topology	Family	Provenance Source (Version)
A	Profilin	e1a0kA1	A: a+b three layers	X: Profilin-like	H: profilin-like (From Topology)	T: profilin-like	F: Profilin	ECOD (1.6)

Domain Annotation: CATH

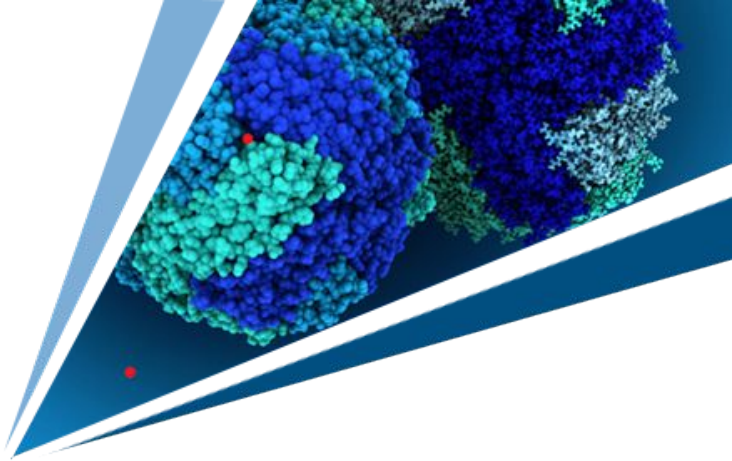
CATH Database Homepage

Chain	Domain	Class	Architecture	Topology	Homology	Provenance Source (Version)
A	3.30.450.30	Alpha Beta	2-Layer Sandwich	Beta-Lactamase	Dynein light chain 2a, cytoplasmic	CATH (4.2.0)

Data API provides information seen on the “Annotations” tab

RCSB.org: Positional Features

RCSB.org APIs provide information seen on the 1D-3D "Protein Feature View"



RCSB.org Data Schema

Supports Search and Data APIs

What is Schema?

- Schema is metadata: Provides information about how data is structured
- Schema in the context of databases (data schema or data model)
  - Schema provides organization, structure, and architecture for a database
  - Describes the shape of the database and how different data tables or objects relate to one another
  - Applicable to both relational and document-oriented databases
- Schema in the context of APIs
  - Like database schemas but for APIs
  - Describes API operations and how to interact with APIs

RCSB.org Data Schema

- Follows the PDBx/mmCIF data dictionary
  - Data standard followed by the PDB archive
  - Definitions for macromolecular structures and associated metadata
  - Dictionary definition language supports specifications for data types, controlled vocabularies, mandatory attributes
  - Designed to be extensible and has software support
  - Virtual crash course: https://pdb101.rcsb.org/train/training-events/mmcif
- RCSB extension with additional definitions
  - Definitions specific for RCSB.org data delivery
  - Definitions for annotations integrated from external resources
  - Prefixed with "*rcsb_*"
- Data organization based on molecular hierarchy
  - Core objects: Entry, Entity, Entity Instance, Assembly, Chemical Component
- Powered by JSON schema language

https://data.rcsb.org/index.html#data-schema

PDBx/mmCIF Data in JSON Format

JSON Data Format

```
{
    "key1": "value1",
    "key2": "value2",
}
```

PDB Data in JSON Format

```
{
    "id": "4HHB",
    "title": "THE CRYSTAL STRUCTURE OF HUMAN
              DEOXYHAEMOGLOBIN AT 1.74
              ANGSTROMS RESOLUTION",
    "method": "X-RAY DIFFRACTION",
}
```

Source data from PDBx/mmCIF

```
_exptl.entry_id              4HHB
_exptl.method                'X-RAY DIFFRACTION'
_exptl.crystals_number       ?
```

Keys (objects and attributes)

Values

```
_struct.entry_id                     '4HHB'
_struct.title
; THE CRYSTAL STRUCTURE OF HUMAN
DEOXYHAEMOGLOBIN AT 1.74 ANGSTROMS RESOLUTION
;
_struct.pdbx_descriptor              'HEMOGLOBIN (DEOXY)'
_struct.pdbx_model_details           ?
_struct.pdbx_CASP_flag               ?
_struct.pdbx_model_type_details      ?
```

RCSB Extension: Common Data Objects

- Positional features
  - Entities and instances: rcsb_<core_object>_feature
  - Example: CATH, SCOP, ECOD, mutations, model quality metrics, validation metrics, ligand binding sites, accessible surface area
- Positional feature summaries
  - Entities and instances: rcsb_<core_object>_feature_summary
  - Feature statistics: count, coverage, minimum value, maximum value
- Annotations
  - Entities and instances: rcsb_<core_object>_annotation
  - Example: GO, InterPro, Pfam
- Provenance information: PDB or other data source

Examples

Data fetched from the Data API


```
{
  "data": {
    "entry": {
      "rcsb_id": "4HHB",
      "exptl": [
        {
          "method": "X-RAY DIFFRACTION"
        }
      ],
      "polymer_entities": [
        {
          "rcsb_id": "4HHB_1",
          "rcsb_polymer_entity_annotation": [
            {
              "annotation_id": "PF00042",
              "description": null,
              "name": "Globin (Globin)",
              "provenance_source": "Pfam",
              "type": "Pfam"
            },
            {
              "annotation_id": "GO:0072562",
              "description": null,
              "name": "blood microparticle",
              "provenance_source": "UniProt",
              "type": "GO"
            },
```


Data from PDBx/mmCIF

Data in PDBx/mmCIF

```
_exptl.entry_id                  4HHB
_exptl.method                    'X-RAY DIFFRACTION'
_exptl.crystals_number           ?
```

Annotations integrated from external resources

Data fetched from the Data API


```
{
  "data": {
    "polymer_entity_instance": {
      "rcsb_id": "4HHB.A",
      "rcsb_polymer_instance_feature": [
        {
          "description": "Software generated binding site for ligand entity 3
component HEM instance G chain B",
          "name": "ligand HEM",
          "provenance_source": "PDB",
          "type": "BINDING_SITE",
          "feature_positions": [
            {
              "beg_seq_id": 53,
              "end_seq_id": null
            }
```


Positional features from the PDB

Data fetched from the Data API

Data from PDBx/mmCIF


```
"assemblies": [
  {
    "rcsb_id": "4HHB-1",
    "pdbx_struct_assembly": {
      "id": "1",
      "oligomeric_count": 4,
      "oligomeric_details": "tetrameric",
      "method_details": "PISA"
    },
    "rcsb_assembly_info": {
      "assembly_id": "1",
      "nonpolymer_entity_count": 2,
      "nonpolymer_entity_instance_count": 6,
      "polymer_composition": "heteromeric protein",
      "polymer_entity_count": 2,
      "polymer_entity_count_protein": 2,
      "polymer_entity_instance_count": 4,
      "polymer_entity_instance_count_protein": 4,
      "total_number_interface_residues": 175
    },
```

Summary

- RCSB.org is powered by APIs
  - Search API provides programmatic access to all functionalities supported by RCSB.org basic and advanced search
  - Data API provides programmatic access all static data delivered on RCSB.org
  - Available to all users

- RCSB.org APIs are supported by the underlying data schema
  - Information from the PDB archive in PDBx/mmCIF
  - Information integrated from external resources
  - Data organized and mapped into molecular hierarchy
  - Powered by JSON schema language

Questions

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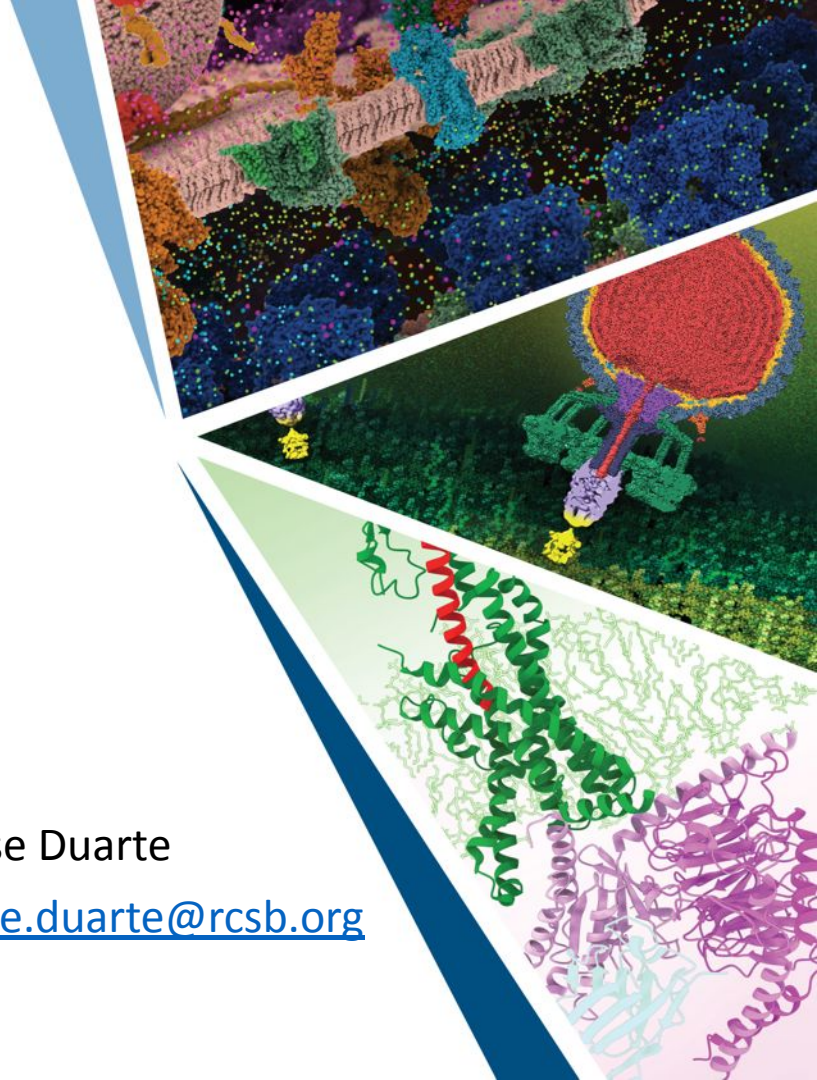


RCSB PDB Data API

Leveraging RCSB PDB APIs for Bioinformatics Analyses and Machine Learning

October 12th, 2023

Jose Duarte

jose.duarte@rcsb.org

Data API: What Is It

Retrieve data once you know **identifiers**

Identifiers may come from external API/resource, references in some publication …

If identifiers not known: use Search API first. Typical workflow:

1. Use **Search API** to find identifiers that match a specific set of conditions
2. For each identifier, use **Data API** to retrieve data related to the identifier

Interfaces for Data API

REST

```
https://data.rcsb.org/rest/v1/core/entry/{entry_id}
https://data.rcsb.org/rest/v1/core/assembly/{entry_id}/{assembly_id}
```

- Endpoints per granularity
- Get ALL data for given object
- Note some endpoints are offered only in REST (e.g. holdings)

GraphQL

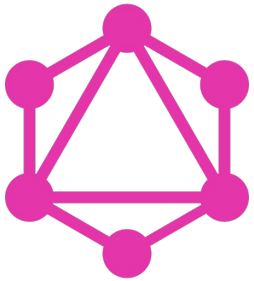
- Single entry point that can traverse the entire schema
- Get only the data you need for your use-case
- JSON-based query language

```
{
  entry(entry_id: "4HHB") {
    exptl {
      method
    }
  }
}
```

The output is in JSON format

GraphQL Basics

```
{
  entry(entry_id: "4HHB") {
    exptl {
      method
    }
  }
}
```



Graph Query Language

Why GraphQL: prevent under and over-fetching

Despite its name: it is NOT a query language that can be used to express a search condition

Error handling in GraphQL: not your standard http response codes

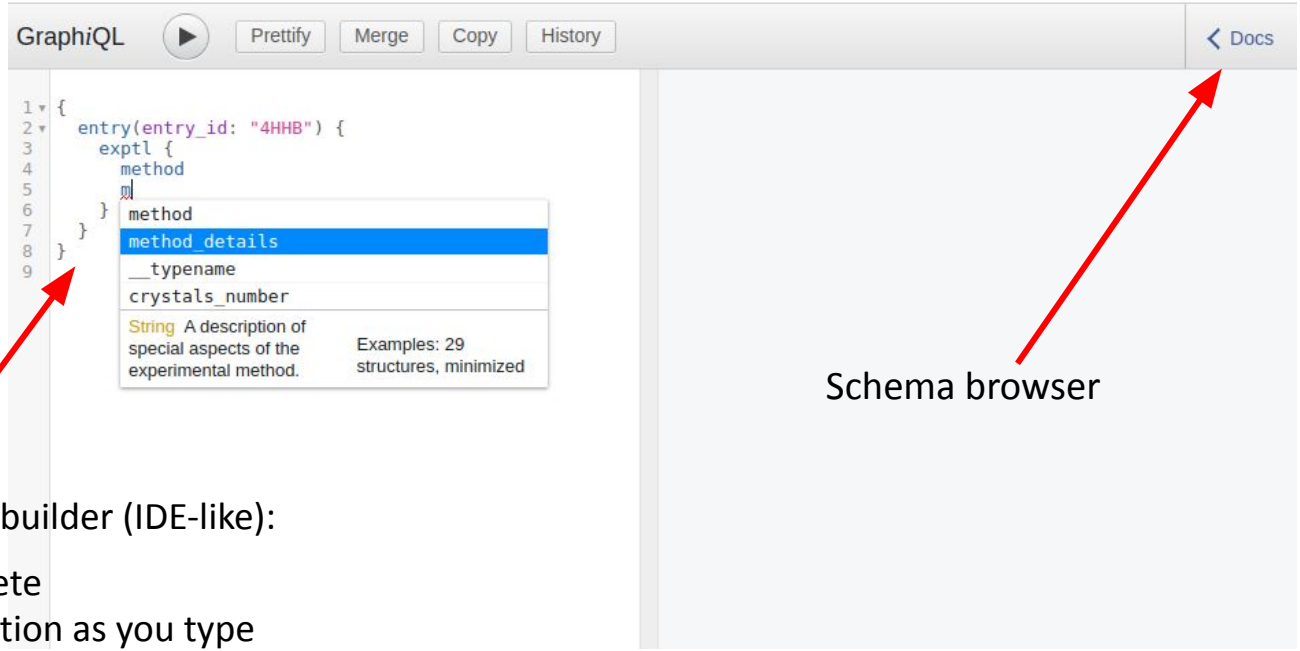
- All queries return 200 response code
- Errors come in the response payload in json format

GraphQL Tooling

Very large ecosystem of tools in many languages: exploration tools, IDEs, visualization tools, editors, validators, automatic type generation

Most importantly: plenty of client implementations

The Graph*i*QL Tool



Interactive query builder (IDE-like):

- Autocomplete
- Documentation as you type
- Navigating to schema

https://data.rcsb.org/graphql/index.html

Submitting a Query

Both GET and POST available for query submission

GET example:

```
https://data.rcsb.org/graphql?query={entry(entry_id:"4HHB"){exptl{method}}}
```

URL encoded:

```
https://data.rcsb.org/graphql?query=%7Bentry%28entry_id%3A%224HHB%22%29%7Bexptl%7Bmethod%7D%7D%7D
```

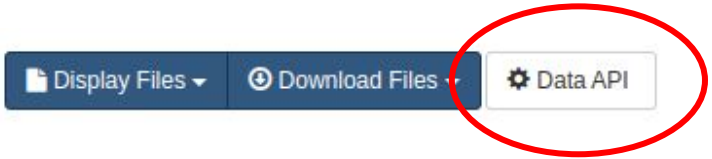
We recommend using a client: it will take care of everything. Especially important for error handling.

Query by Example

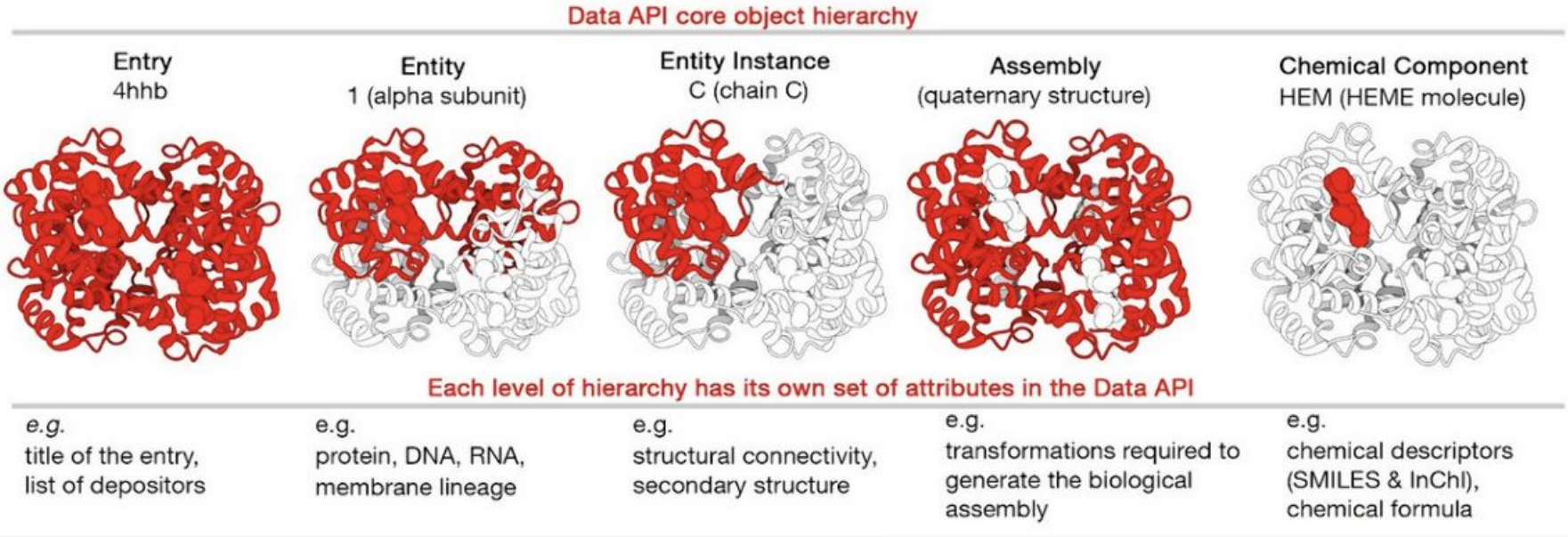
The Data API button in rcsb.org. Present in:

- Structure Summary Pages and tabs
- Ligand Summary Pages

Gets the data that is needed to render the page



Reminder: PDB Data Hierarchy (Granularities)



Identifiers "*rcsb_id*"	4HHB	4HHB_1	4HHB.C	4HHB-1	HEM

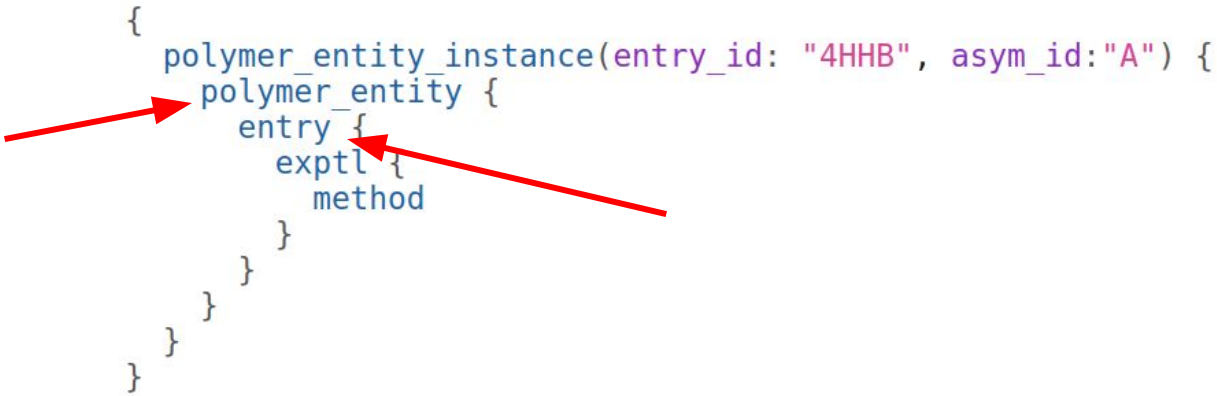
Connections Between Granularity Levels

- Top level accessors for each granularity in 2 flavours: single and list

```
entry(entry_id: "4HHB")
entries(entry_ids: ["4HHB", "3HBX"])
```

```
assembly(entry_id: "4HHB", assembly_id: "1")
assemblies(assembly_ids: ["4HHB-1", "3HBX-1"])
```

- Connection accessors from other granularity levels



```
{
  polymer_entity_instance(entry_id: "4HHB", asym_id:"A") {
    polymer_entity {
      entry {
        exptl {
          method
        }
      }
    }
  }
}
```

Some Examples

Title, experimental method and resolution and Rfree for some entries

Organisms and cluster membership of polymeric entities

Annotations at chain level (e.g. CATH or SCOP)

Data associated to a Computed Structure Model (e.g. pLDDT)

Interface properties for a certain assembly

FAQ

Q: How do I find what field has the data I want?

A: Query by example, GraphiQL schema browser and contextual help

Q: Does the request allow for filtering?

A: No. Filtering must be done by consumer

Q: How do I get data for the whole archive?

A: Holdings REST endpoint and GraphQL queries by batches

Resources

Tutorial and many examples at: https://data.rcsb.org

The full list of data attributes:
https://data.rcsb.org/data-attributes.html

The schema browser in GraphiQL:
https://data.rcsb.org/graphql/index.html (“Docs” link on top right)

Reference for REST endpoints: https://data.rcsb.org/redoc/index.html

Questions?

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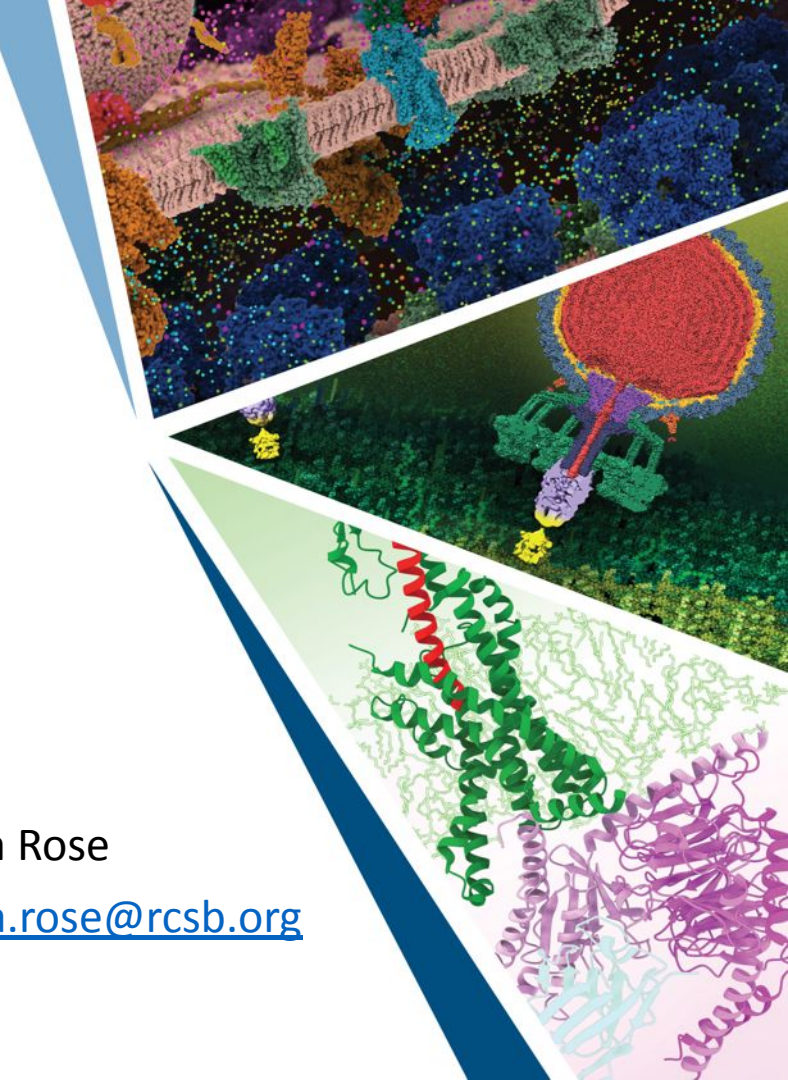
PROTEIN DATA BANK

RCSB.org

info@rcsb.org



RCSB PDB Search API

Leveraging RCSB PDB APIs for Bioinformatics Analyses and Machine Learning

October 12th, 2023

Yana Rose

yana.rose@rcsb.org

RCSB PDB Search API: Introduction

- In this session, we'll dive into the RCSB PDB Search API's capabilities. You'll learn how to utilize advanced query options tailored to the needs of structural bioinformaticians
- Search API is a powerful tool that allows you to programmatically query the RCSB PDB data
- REST over HTTP using JSON
- Search API defines a language for writing complex queries that can be used to retrieve a list of the PDB IDs that match these criteria

Overview of Available Search Options

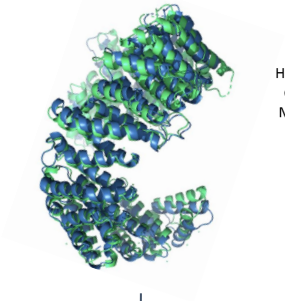
Text Search

Structures with metadata that matches specific keywords or values, e.g. release date, resolution, experimental details, taxonomy

_exptl.method
X-RAY DIFFRACTION

Structure

Assemblies and chains resembling a target, in terms of the global volumetric shape



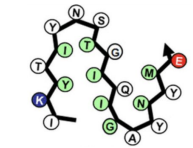
Sequence

"Homologous" nucleotide or protein sequences, statistically significant similarity that reflects common ancestry

```
HUMAN KKASKPKKAASKAPTKKPKATPVKKAKKK
CHIMP KKASKPKKAASKAPTKKPKATPVKKAKKK
MOUSE KKAAKPKKAASKAPSKKPKATPVKKAKKK
RAT   KKAAKPKKAASKAPSKKPKATPVKKAKKK
COW   KKAAKPKKAASKAPSKKPKATPVKKAKKK
```

Sequence Motif

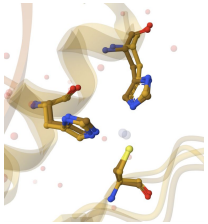
Related sequences that share small conserved regions (motifs) that have biological meaning



```
DESIKYTIYNSTGIQIGAYNYMEI
DESSKYTIHSSSGIQIGDSNYMEI
DDLIKYTIFNSSGIQIGNHNYMDV
EDSIMYNITNSSGIQIGSHNHMKI
```

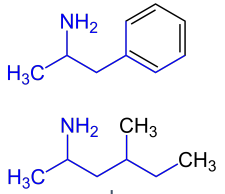
Structure Motif

Assemblies with similar patterns of local structure associated with function, e.g. catalytic sites



Chemical

Small molecules which are similar to the query chemical structure, in terms of calculated molecular descriptors or "fingerprints"

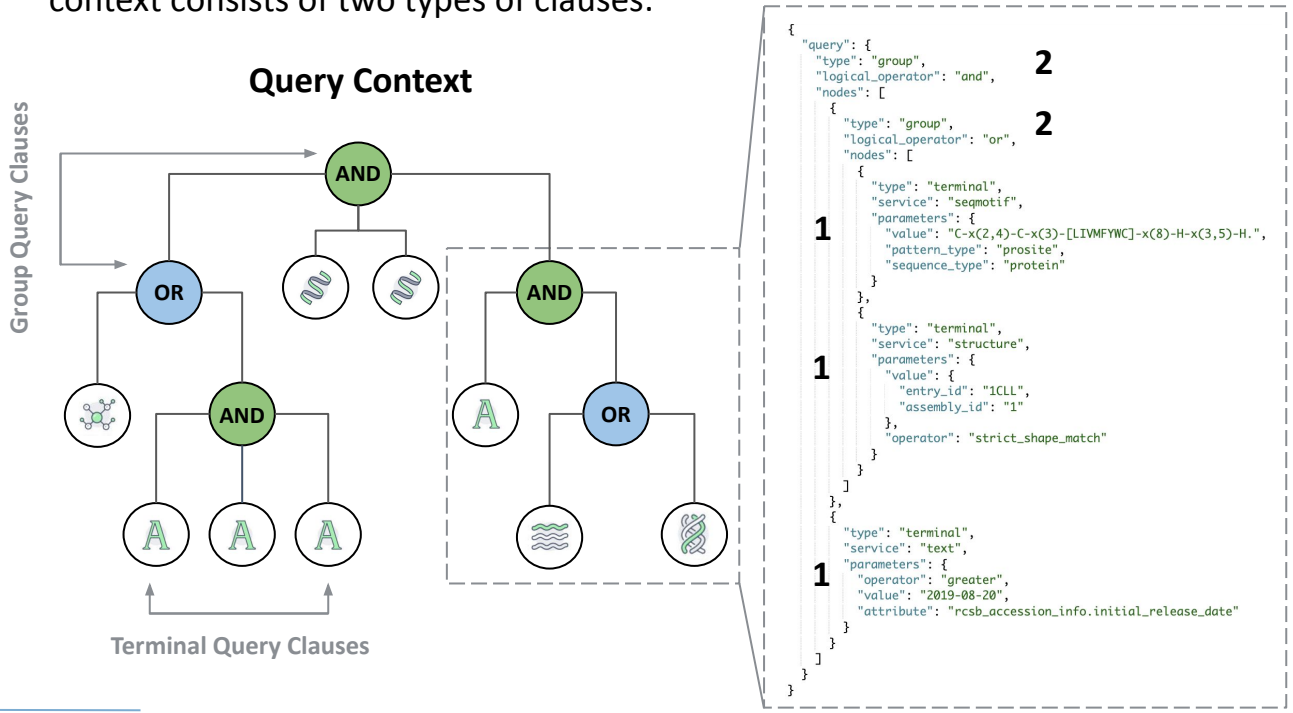


AND **OR**

1BFB, 1KHT, 2J9Z, 2LBG, 3ZOE, 4BIK

Search API: Query Language

Search API provides a full DSL (Domain Specific Language) based on JSON to define queries. Query context consists of two types of clauses:



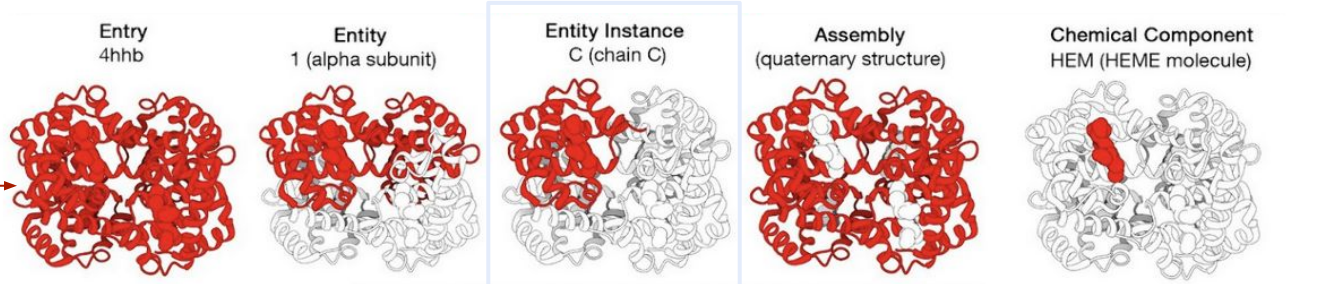
1. **Terminal Query Clauses**: individual search criteria, e.g. match a particular value in a particular field or run a sequence search
2. **Group Query Clauses**: wrap other terminal or group queries and are used to combine multiple queries in a logical fashion (AND, OR)

https://search.rcsb.org/#query-language

Search API: Return Type

Underlying macromolecular structure hierarchy progresses from atoms through amino acids and chains to assemblies of interacting macromolecules and ligands. Search API can return identifiers for the following levels:

```
{
  "query": {
    "type": "terminal",
    "service": "text",
    "parameters": {
      "attribute": "exptl.method",
      "operator": "exact_match",
      "value": "ELECTRON MICROSCOPY"
    }
  },
  "return_type": "entry"
}
```



	`"entry"`	`"polymer_entity"`	`"polymer_instance"`	`"assembly"`	`"non_polymer_entity"` `"mol_definition"`
RCSB PDB identifiers:	4HHB	4HHB_1	4HHB.C	4HHB-1	4HHB_3 HEM

Instance identifier corresponds to the ***_label_asym_id*** from the mmCIF schema (assigned by the PDB). It can differ from ***_auth_asym_id*** (selected by the author at the time of deposition)

Search API: Request Options

Request Options context determines what is included in a search response:

Include Computed Structures:

```
{
  "request_options": {
    "results_content_type": ["exerimental", "computational"],
    "paginate": {
      "start": 0,
      "rows": 2
    }
  }
}
```

```
"result_set": [
  {
    "identifier": "4HHB_1",
    "score": 1
  },
  {
    "identifier": "AF_AFQ9TS34F1_1",
    "score": 0.8455896140654742
  }
]
```

Return All Hits:

```
{
  "request_options": {
    "results_verbosity": "compact",
    "return_all_hits": true
  }
}
```

```
"result_set": [
  "4HHB_1",
  "1XXT_1",
  "1Y85_1",
  "1Y7C_1",
  "1A0U_1",
  "1Y7G_1",
```

Redundancy Filter:

```
{
  "request_options": {
    "group_by": {
      "aggregation_method": "sequence_identity",
      "similarity_cutoff": 30
    },
    "group_by_return_type":"representatives"
  }
}
```

Sorting:

```
{
  "request_options": {
    "sort": [
      {
        "sort_by": "rcsb_accession_info.initial_release_date",
        "direction": "desc"
      }
    ]
  }
}
```

Reference Documentation Live Demo

Search API is documented with the OpenAPI Specification (https://swagger.io/specification). This reference documentation describes how to use the endpoints Search API is exposing:

```
{
  "openapi" : "3.0.1",
  "info" : {
    "title" : "RCSB Search API",
    "description" : "Provides programmatic access to RCSB search API.",
    "termsOfService" : "https://www.rcsb.org",
    "contact" : {
      "email" : "info@rcsb.org"
    },
    "license" : {
      "name" : "Apache 2.0",
      "url" : "https://www.apache.org/licenses/LICENSE-2.0.html"
    },
    "version" : "2.4.0"
  },
  "servers" : [ {
    "url" : "/rcsbsearch/v2/"
  } ],
  "paths" : {
```

Download: https://search.rcsb.org/openapi.json

UI: https://search.rcsb.org/redoc/index.html

Attributes Available for Search

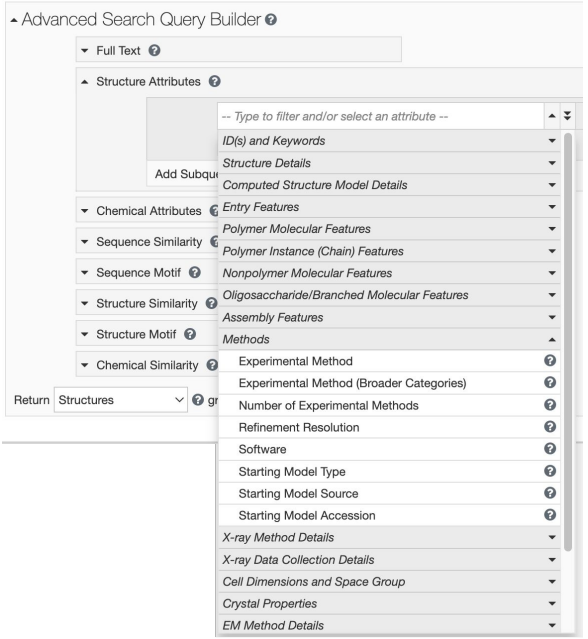
API endpoint:
https://search.rcsb.org/rcsbsearch/v2/metadata/schema

Comprehensive documentation:
https://search.rcsb.org/structure-search-attributes.html

release_date

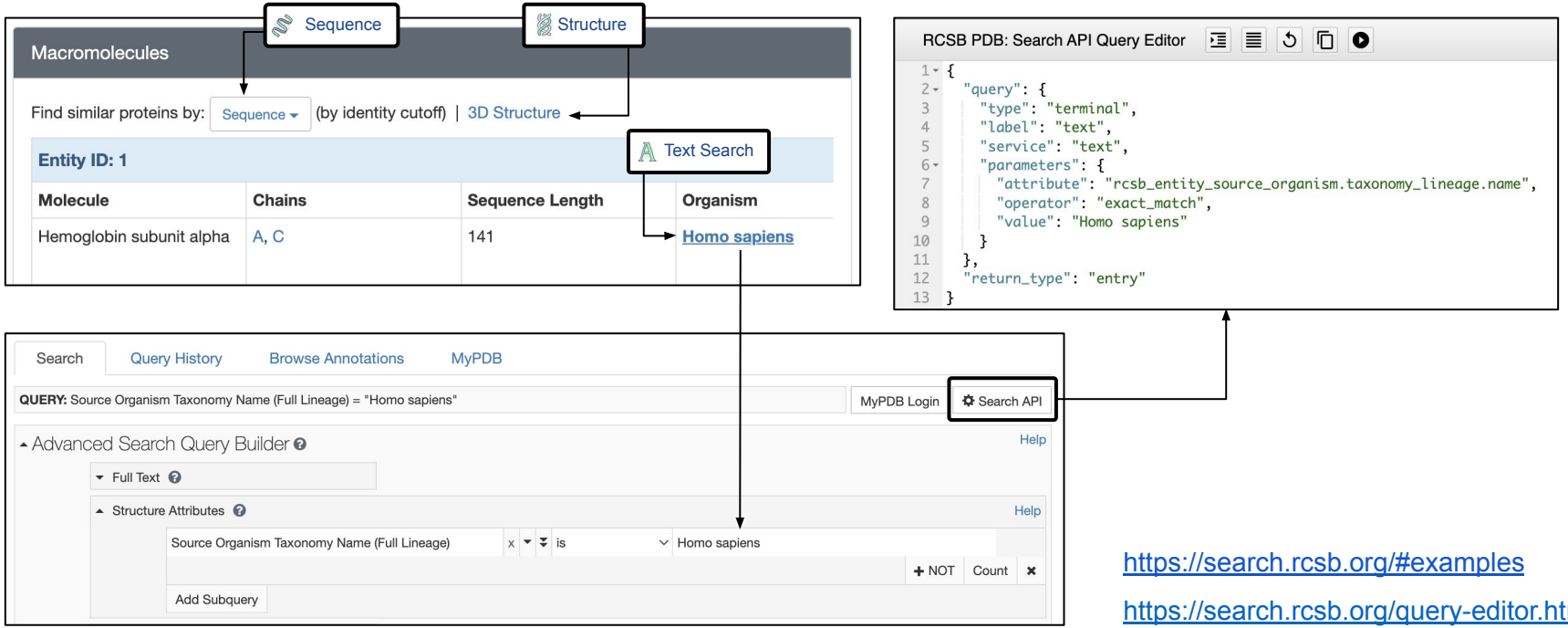
Attribute	Operators	Type	Description
rcsb_accession_info.initial_release_date	equals greater less greater_or_equal less_or_equal range exists	date	The entry initial release date.

RCSB.org UI:
https://www.rcsb.org/search/advanced



Search API: Query by Example

https://www.rcsb.org/structure/4HHB



https://search.rcsb.org/#examples

https://search.rcsb.org/query-editor.html

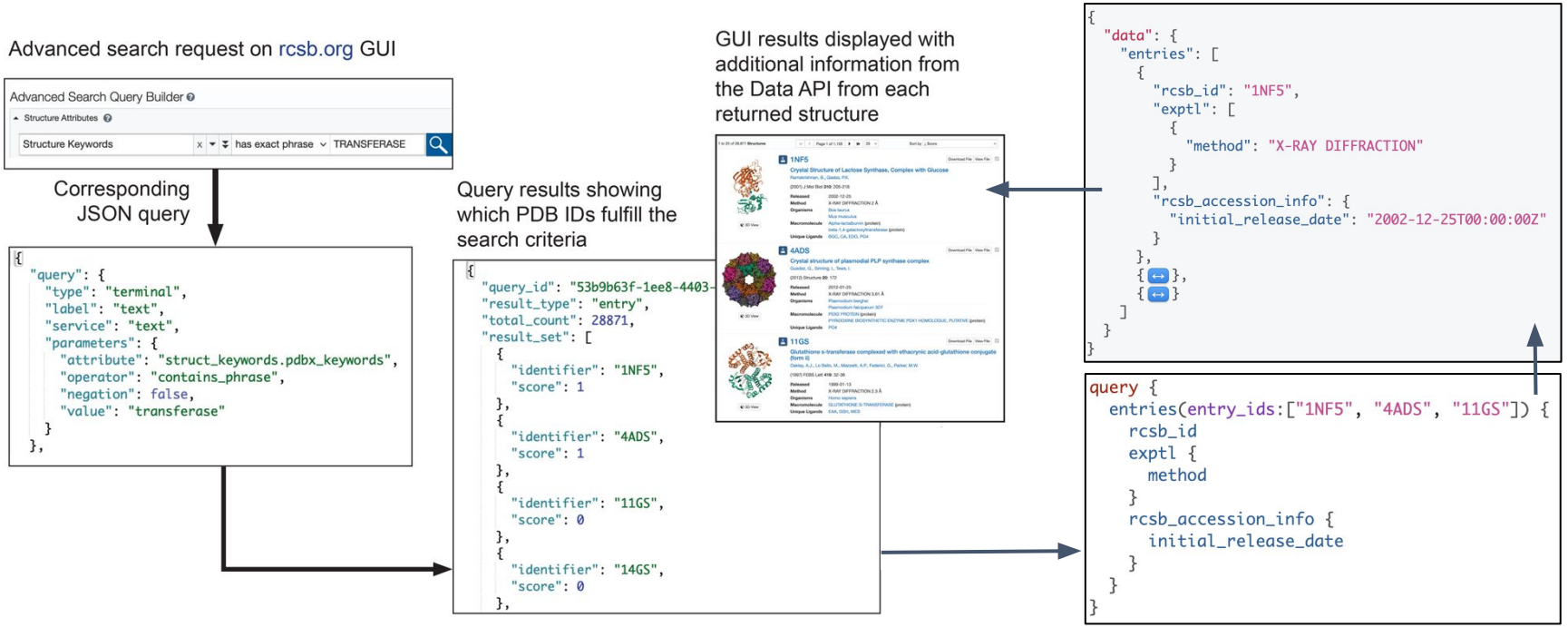
Useful Resources

Learn more about Search API:

- Reference Documentation: https://search.rcsb.org/redoc/index.html
- User Guide: https://search.rcsb.org/#search-api
- Tutorial: https://pdb101.rcsb.org/learn/guide-to-understanding-pdb-data/introduction-to-rcsb-pdb-apis
- Help Desk: info@rcsb.org

Search API In Real-world Application

Search API powers the search features provided on the RCSB.org



Questions?

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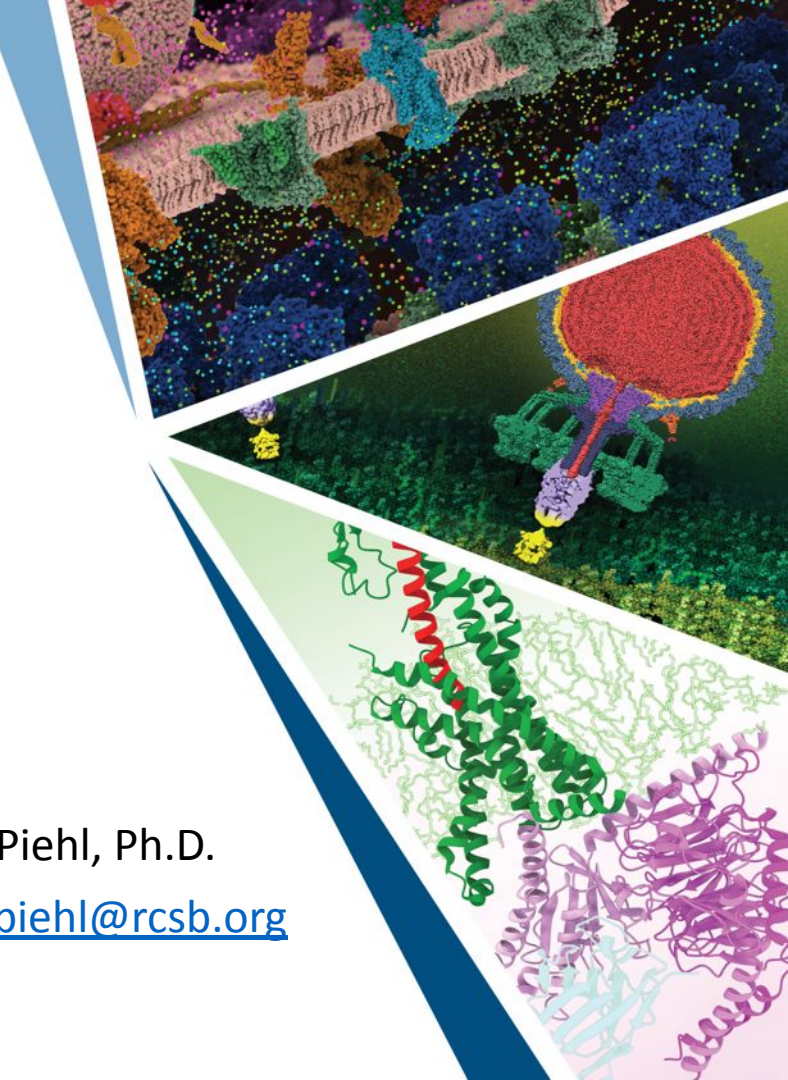


Search and Data API Hands-on Teaser

Leveraging RCSB PDB APIs for Bioinformatics Analyses and Machine Learning

October 12th, 2023

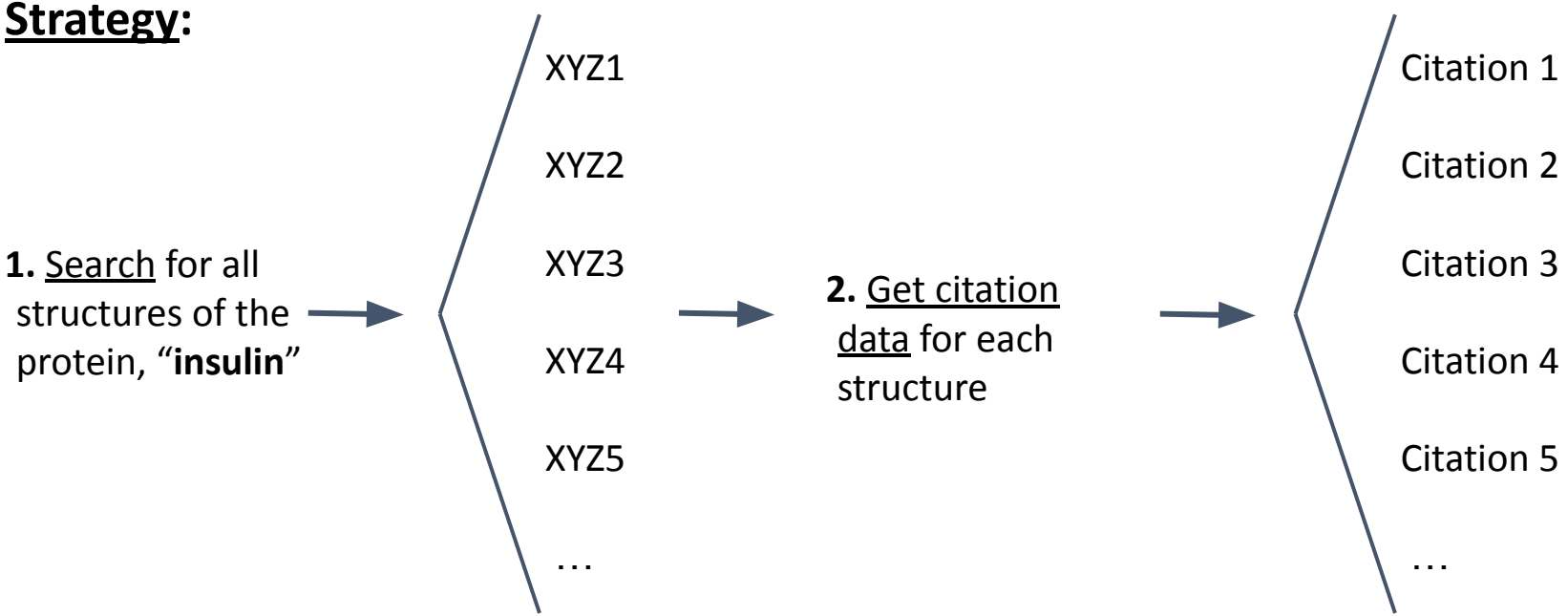
Dennis Piehl, Ph.D.

dennis.piehl@rcsb.org

Search and Data API: Example Pipeline

Goal: *Get the citation information for all structures of insulin.*

Strategy:



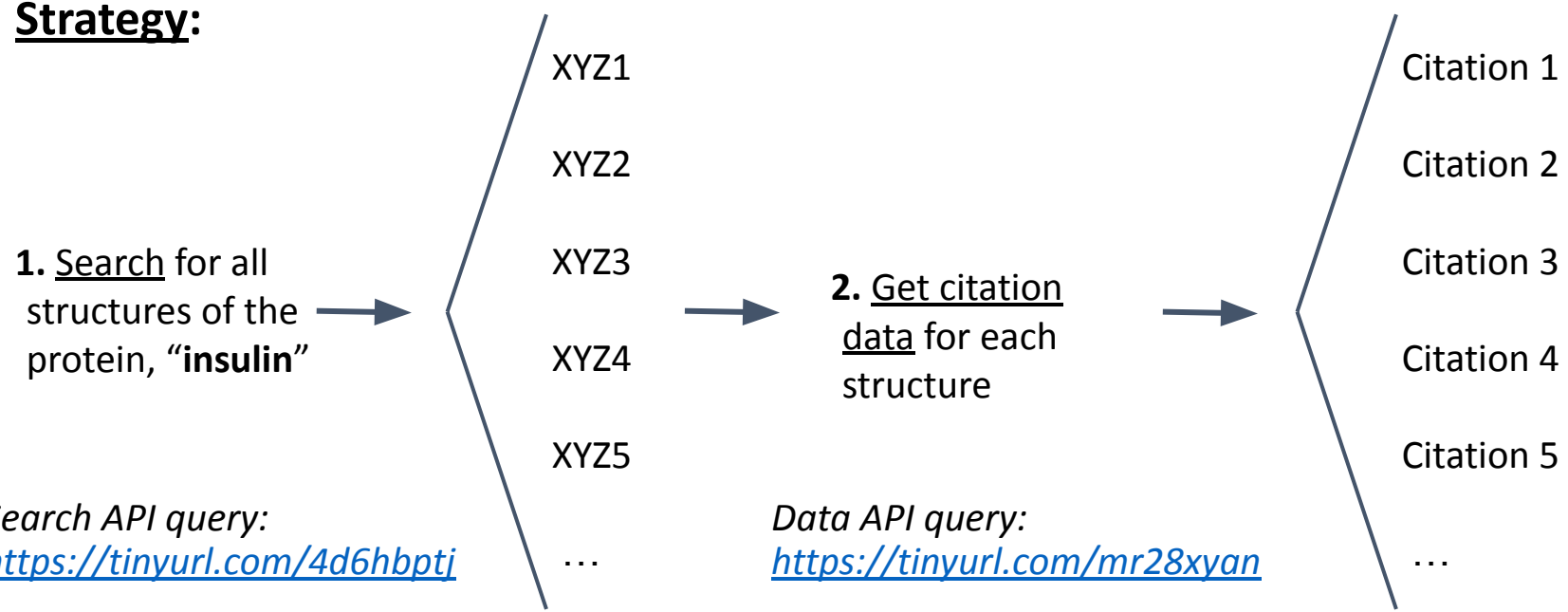
Search and Data API: Example Pipeline

[Live Demo]

Search and Data API: Example Pipeline

Goal: *Get the citation information for all structures of insulin.*

Strategy:



Search API query:
https://tinyurl.com/4d6hbptj

Data API query:
https://tinyurl.com/mr28xyan

Additional Tools and Modes of API Access

- Command-line tools, such as `curl`:

```
curl -X GET "https://search.rcsb.org/rcsbsearch/v2/query?json=..."
```

- Programming libraries, such as Python, e.g.:
  - Python's `requests` module:

```
requests.get("https://search.rcsb.org/rcsbsearch/v2/query?json=...")
```

  - Python's GraphQL module: https://pypi.org/project/python-graphql-client/

```
client = GraphqlClient(endpoint="https://data.rcsb.org/graphql")
```

- [*NEW*] RCSB PDB Search API Python package: rcsbsearchapi.readthedocs.io

RCSB PDB Search API Python Package

- [*NEW*] RCSB PDB Search API Python package: rcsbsearchapi.readthedocs.io
  - Access search API via Python interface
  - Install from PyPI or GitHub (https://github.com/rcsb/py-rcsbsearchapi)
- QuickStart tutorial: rcsbsearchapi.readthedocs.io/en/latest/quickstart.html

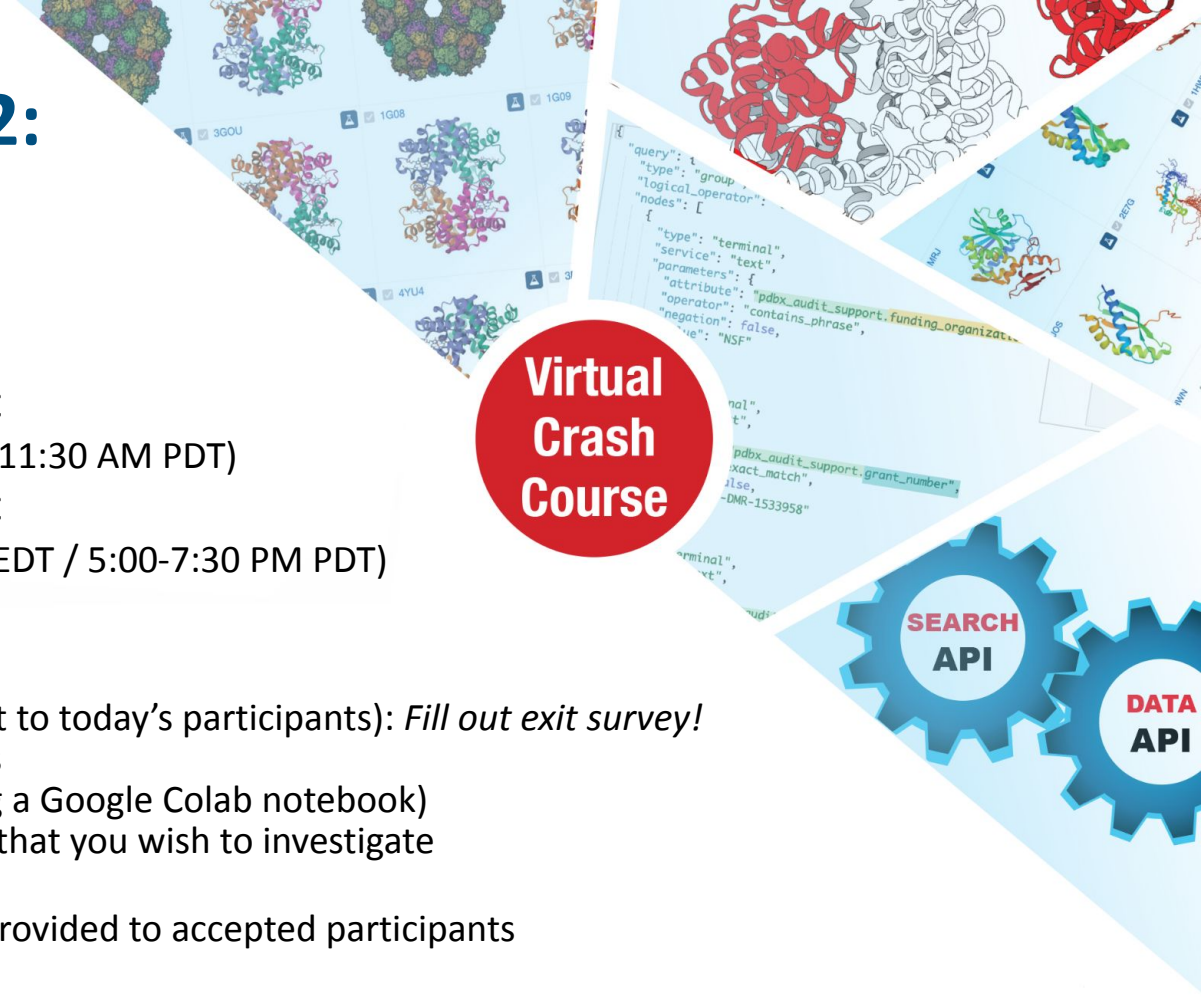
```
from rcsbsearchapi.search import TextQuery
from rcsbsearchapi import rcsb_attributes as attrs

# Create terminals for each query
q1 = TextQuery("heat-shock transcription factor")
q2 = attrs.rcsb_struct_symmetry.symbol == "C2"
q3 = attrs.rcsb_struct_symmetry.kind == "Global Symmetry"
q4 = attrs.rcsb_entry_info.polymer_entity_count_DNA >= 1

# combined using bitwise operators (&, |, ~, etc)
query = q1 & (q2 & q3 & q4)

# Call the query to execute it
for assemblyid in query("assembly"):
    print(assemblyid)
```

Register for Part 2: Hands-on APIs



Offered at two different times:

- **October 19** 16:00 - 18:30 UTC
  (12:00 - 2:30 PM EDT / 9:00 - 11:30 AM PDT)
- **October 27** 00:00 - 02:30 UTC
  (**October 26** 8:00 - 10:30 PM EDT / 5:00-7:30 PM PDT)

Requirements for participation:

- Registration (form will be sent to today's participants): *Fill out exit survey!*
- Familiarity with Python basics
- Google account (for accessing a Google Colab notebook)
- Questions and real use cases that you wish to investigate

Space is limited; Zoom link will be provided to accepted participants

Part 2 Teaser: Hands-on ML/AI use case

- Learn how to create a dataset to use for training ML/AI models

- Use case will focus on predicting protein-protein binding sites:
  - Search for hetero-dimer complexes
  - Use biological features/annotations from Data API to remove redundancy and/or split between training and testing sets

- Explore how to map positional features onto structures:
  - Secondary structure
  - Binding site residues

RCSB PDB Team

RCSB.ORG
info@rcsb.org

Core Operations Funding

National Science Foundation (DBI-1832184), National Institute of General Medical Sciences, National Institute of Allergy and Infectious Disease, and National Cancer Institute (NIH R01GM133198), and the US Department of Energy (DE-SC0019749)

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Summer Scholars Emma and Jordi beta testing the Bound! card game

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