

Diving into JUMP Cell Painting data: Facilitating novel discoveries through accessible tools

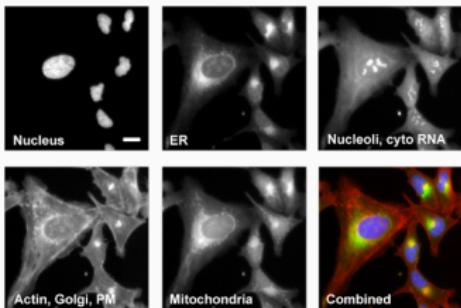
Alán Muñoz

May 5, 2024

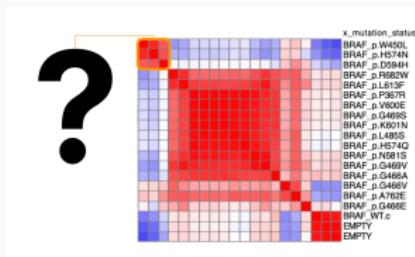
Introduction: Turns out high content imaging is hard.

The JUMP-CP Consortium produced large diverse datasets

- Raw images



- Morphological profiles



- Metadata tables



- Notebooks

A screenshot of a Jupyter Notebook interface. The code cell contains the following Python code:

```
# This cell contains the raw Jupyter notebook code for the analysis.
```

The output cell shows the results of the analysis, including a heatmap and some text output.

Why is this a problem of scale?

- Loads of data
 - ~115k chemical perturbations
 - ~15k genes (KO'd, overexpressed or both).

Why is this a problem of scale?

- Scattered metadata
 - How do we visualise the images from which a profile was produced?
 - Are these two perturbations from the same batch/plate?

Why is this a problem of scale?

- Diverse backgrounds
 - How can biologists with limited coding experience benefit?
 - How can developers build their own tools?

We aim to help scientists further
their research

We use our own use-cases to make the data useful

I have -omics data for X modified gene or chemical compound.

- How do cells affected by X look?

We use our own use-cases to make the data useful

I have -omics data for X modified gene or chemical compound.

- What else produces similar morphologies?

We use our own use-cases to make the data useful

I have -omics data for X modified gene or chemical compound.

- What are the distinctive features of X-perturbed cells?

We use our own use-cases to make the data useful

I have -omics data for X modified gene or chemical compound.

- Can my X be found under a different name?

Ease of access: We preprocess data publish it using WebAssembly

- **Process data:** `jump_rr` (JUMP Round-Robin) is our tool to perform pairwise computations on profiles and their metadata on GPUs.

Ease of access: We preprocess data publish it using WebAssembly

- Publish results: `Datasette` is a Python library to visualise, query and edit databases.

What else produces similar morphologies?

matches: Find the most similar (and dissimilar) perturbations.

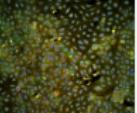
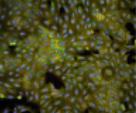
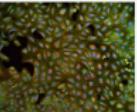
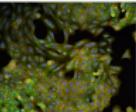
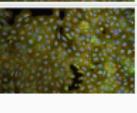
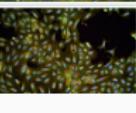
home / data

content

50 rows where Gene/Compound = "MYT1" sorted by Similarity descending

Gene/Compound: - column -
 % [View and edit SQL](#)

This data as [json](#), [CSV \(advanced\)](#)

Link	rowid	index	Gene/Compound	Match	Gene/Compound Example	Match Example	Similarity ▲	Match resources	JCP2022
47551	47551	47550	MYT1	SOS1			0.7195221781730652	External	JCP2022_804400
47552	47552	47551	MYT1	IL13RA2			0.6865948567390442	External	JCP2022_804400
47553	47553	47552	MYT1	NLRP12			0.678930401802063	External	JCP2022_804400

home

What else produces similar morphologies?

What are the distinctive features of X-perturbed cells?

feature: Find the most distinctive features of a perturbation, or amongst all.

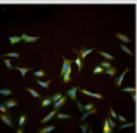
67,700 rows

- column - =

Apply

% View and edit SQL

This data as [json](#), [CSV \(advanced\)](#)

Link	rowid	Index	Mask	Feature	Channel	Statistic	Gene/Compound	Metadata_image	Median	JCP2022
1	1	0	Cells	Correlation_K_Mito	AGP	8.349928508374835e-29	AVPR2		-0.21309228714749423	JCP2022_905491
2	2	1	Cells	Correlation_K_Mito	AGP	3.325815194945794e-19	EEF1AKMT2		0.13034929387328936	JCP2022_912740

normal

What are the distinctive features of X-perturbed cells?

How do cells affected by X look?

gallery: Explore all the images with an associated profile.

12 rows where Gene/Compound in ["MYT1", "PROZ"] sorted by rowid

Gene/Compound:	in	=	MYT1, PROZ
- column -	=	=	
<input type="button" value="Apply"/>			

[View and edit SQL](#)

This data as [json](#), [CSV \(advanced\)](#)

Link	rowid	Index	Gene/Compound	External resources	Metadata_JCP2022	Foci 0	Foci 1	Foci 2	Foci 3	Foci 4	Foci 5	Foci 6	Foci 7	Foci 8	
	6	6	5	PROZ	External	JCP2022_805564									
	1055	1055	1054	MYT1	External	JCP2022_804400									
	9671	9671	9670	PROZ	External	JCP2022_805564									
	10704	10704	10703	MYT1	External	JCP2022_804400									
	19344	19344	19343	PROZ	External	JCP2022_805564									
	20390	20390	20389	MYT1	External	JCP2022_804400									
	29042	29042	29041	MYT1	External	JCP2022_804400									
	29521	29521	29520	PROZ	External	JCP2022_805564									

more!

How do cells affected by X look?

Does X have a different name in other databases?

broad_babel: Translates IDs (JUMP, Symbol/InChiKey, Entrez id, Broad) and which are controls.

The screenshot shows a web-based application interface for managing gene mappings. At the top, there's a header bar with a blue background containing the text "home / babel". Below the header, the main title is "babel" in a large, bold, black font. Underneath the title, it says "140,843 rows". There are several input fields and buttons: a dropdown menu for "column", a search bar with placeholder text "Search", and a blue "Apply" button. Below these, there's a link to "View and edit SQL". A note indicates "This data as [json, CSV (advanced)]". The main content is a table with 16 rows, each containing gene information. The columns are: Link, rowid, JCP2022, NCBI_Gene_ID, standard_key, broad_sample, and pert_type. The data includes various genes like NAT1, AANAT, ABAT, ACADVL, ASIC1, and ACTN4, along with their corresponding identifiers and sample types. At the bottom right of the table, there's a small "Done" button.

Link	rowid	JCP2022	NCBI_Gene_ID	standard_key	broad_sample	pert_type
1	1	JCP2022_900002	9	NAT1	ccsbBroad304_00001	trt
2	2	JCP2022_900003	15	AANAT	ccsbBroad304_00002	trt
3	3	JCP2022_900004	18	ABAT	ccsbBroad304_00003	trt
4	4	JCP2022_900005	37	ACADVL	ccsbBroad304_00007	trt
5	5	JCP2022_900006	41	ASIC1	BRDN0001485349	trt
6	6	JCP2022_900006	41	ASIC1	BRDN0001480309	trt
7	7	JCP2022_900006	41	ASIC1	ccsbBroad304_00008	trt
8	8	JCP2022_900007	47	ACLY	ccsbBroad304_00009	trt
9	9	JCP2022_900008	48	ACO1	ccsbBroad304_00010	trt
10	10	JCP2022_900009	52	ACP1	ccsbBroad304_00011	trt
11	11	JCP2022_900010	54	ACP5	ccsbBroad304_00012	trt
12	12	JCP2022_900011	56	ACRV1	ccsbBroad304_00013	trt
13	13	JCP2022_900012	59	ACTA2	ccsbBroad304_00014	trt
14	14	JCP2022_900013	70	ACTC1	ccsbBroad304_00015	trt
15	15	JCP2022_900014	81	ACTN4	ccsbBroad304_00016	trt
16	16	JCP2022_900015	88	ACTN2	ccsbBroad304_00017	trt

To summarise the available data

Perturbation	Match perturbations	Distinctive features	Images
Overexpression	orf	orf_feature	orf_gallery
Knocked-Out	crispr	WIP	crispr_gallery
Compound	WIP	WIP	compound_gallery

For example:

- broad.io/orf
- broad.io/orf_feature
- broad.io/orf_gallery

Additionally, a table with all the available gene and their other ids:

- broad.io/babel

broad_babel: Obtain metadata

Translates identifiers and provides essential metadata.

- What is the NCBI id of this gene?
- Is **X** perturbation a treatment or a control?

It doubles as a single source of metadata ground truth.

`jump_portrait`: Spice-up your workflow with cell images

Fetch a subset of images associated to a perturbation.
Optionally, include their respective negative controls.

- Images at the site level
- Include plate-specific negative controls, to account for batch effects.
- Can be used to train ML/DL models on images by-request.

Other nice JUMP-adjacent tools

- jump-dti: Aggregate drug-target interaction databases
- cpg-data: Fetch images of Cell Painting Gallery

Final remarks

JUMP central concentrates knowledge

JUMP documentation and examples

How-To Guides > Basic JUMP data access

Other Formats
Jupyter

Basic JUMP data access

This is a tutorial on how to access profiles from the [JUMP Cell Painting datasets](#). We will use polars to fetch the data frames lazily, with the help of `s3fs` and `pyarrow`. We prefer lazy loading because the data can be too big to be handled in memory.

▶ Code

The shapes of the available datasets are:

- a. `cpg0016-jump[crispr]`: CRISPR knockouts genetic perturbations.
- b. `cpg0016-jump[orf]`: Overexpression genetic perturbations.
- c. `cpg0016-jump[compound]`: Chemical perturbations.

Their explicit location is determined by the transformations that produce the datasets. The aws paths of the dataframes are built from a prefix below:

▶ Code

We use a S3FileSystem to avoid the need of credentials.

▶ Code

We will lazy-load the dataframes and print the number of rows and columns

▶ Code

shape: (3, 5)

dataset	#rows	#cols	#Metadata cols	Size (MB)
str	i64	i64	i64	i64
"CRISPR"	51185	3677	4	758
"ORF"	81663	3677	4	1210
"COMPOUND"	804844	3677	4	11926

Let us now focus on the `crispr` dataset and use a regex to select the metadata columns. We will then sample rows and display the overview. Note that the `collect()` method enforces loading some data into memory.

▶ Code

We are working on publishing biological vignettes to showcase the use of morphological data

The screenshot shows a GitHub repository interface for the project "broadinstitute / 2023_32_JUMP_data_only_Hapnetes". The repository has 0 stars and 0 forks. The main page displays a list of pull requests (PRs) under the "Issues" tab. There are 12 open PRs and 3 closed PRs. The open PRs are:

- #22 FOXO3/TGFB short mention (CRISPR) [crispr] - 7 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #20 Definition of ORF and CRISPR similarity clusters [crispr] [wt] - 1 comment, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #19 POLRID, SPATA25 connected to many genes: exploration for MorphMap paper (ORF, but want to check CRISPR) [crispr] [wt] - 3 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #18 Cluster ECH1, UQCRCFS1, SARS2: exploration for MorphMap paper (ORF+CRISPR) [crispr] [wt] - 2 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #16 Cluster GPR176, TSC2201, DPAT1, CHRM4: exploration for MorphMap paper (ORF+CRISPR) [crispr] [wt] - 2 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #15 Find Evotec gene connections to pursue: exploration for MorphMap paper Evotec; (ORF's only) OR (CRISPRs only) [crispr] [wt] - 10 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #14 YAP1 connections: exploration for MorphMap paper (ORF but need to check CRISPR) [crispr] [wt] - 13 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #13 Find gene connections [ORF+CRISPR both] to pursue: exploration for MorphMap paper [crispr] [wt] - 24 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #12 SLC or OR gene superfamilies: exploration for MorphMap paper (ORF's, need to check CRISPR) [crispr] [wt] - 8 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #11 HOOK2 opposite effect than PAFAH1B1, NDEL1, NDEL1: exploration for MorphMap paper (ORF) [wt] - 16 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #10 RAB40B has the opposite phenotypes of PIK3R3/NSYN1: exploration for MorphMap paper (ORF) [wt] - 44 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)
- #9 MYT1-RNF41 exploration for MorphMap paper (ORF) [wt] - 12 comments, 1 review, 1 file change, 1 commit, 1 author, 1 assignee, 1 milestone, 1 day ago by [AnnieCarpenter](#)

At the bottom of the list, there is a note: "ProTip! Exclude everything labeled [bug](#) with [label:bug](#)".

Conclusions

We built tools to solve our challenges and help scientists:

- Web tools for experimentalists to explore their perturbations of interest
- Python libraries for software inclined folks to integrate into their workflows
- A general framework to facilitate sharing results and learning material

Shameless plug: September JUMP Hackathon



CytoData

"JUMP into Cell Painting data"
Hackathon for discoveries from
microscopy images

SAVE THE DATE! **September 17th, 2024**

Broad Institute of Harvard and MIT, Cambridge, MA



Resources

- JUMP CP Consortium: jump-cellpainting.broadinstitute.org
- JUMP information central: broad.io/jump
- Imaging Platform's monorepo: broad.io/monorepo
- Slides:
github.com/afermg/2024_05_JUMPTools_CellCircuits

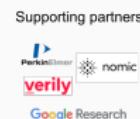
Acknowledgements

Carpenter-Singh Lab

- Anne carpenter
- Shantanu Singh
- Niranj
Chandrasekaran
- John Arevalo
- Sam Chen
- Ankur Kumar
- Ellen Su
- Alex Kalinin
- Adit Shah



Partners



Supporting partners

Collaborators

Scientific:
Horizon Discovery,
a PerkinElmer Company
Administrative:
Pistoia Alliance
Academic:
University of Stanford
Stanford Machine Learning Group