



Swiss Institute of
Bioinformatics

BIOLOGY-INFORMED INTEGRATION AND VISUALIZATION OF
MULTIOMICS DATA

Normalization and Visualization

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February 17-19, 2026

Learning outcomes

- Information from multi-omics datasets
- Heatmap vs EnrichedHeatmap
- Methods for normalizing data in the target regions

ATAC-seq data snapshot

To assess genome-wide chromatin accessibility.

| seqnames | start | end | strand | Symbol | distanceTSS | Group1 | Group2 |
|-----------------|--------------|------------|---------------|---------------|--------------------|---------------|---------------|
| chr1 | 1 | 70 | + | Gene1 | 5000 | 11 | 21 |
| chr1 | 100 | 400 | - | Gene1 | 5000 | 10 | 100 |
| chr1 | 200 | 290 | + | Gene3 | 2000 | 200 | 1000 |
| chr2 | 300 | 500 | - | Gene4 | 3000 | 400 | 1300 |
| chr2 | 20 | 100 | + | Gene5 | 20000 | 20 | 120 |
| chr3 | 40 | 200 | - | Gene6 | 40000 | 540 | 40 |
| chr4 | 15 | 150 | - | Gene7 | 150 | 1500 | 15 |

How can you visualize the ATAC-seq data?



atac seq visualization



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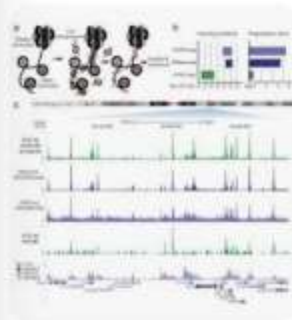
Tools ▾

Saves

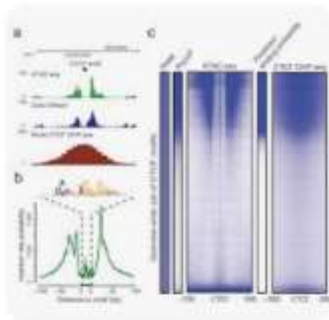


See detailed insights & Compare multiple related Papers for : **"atac seq visualization"**

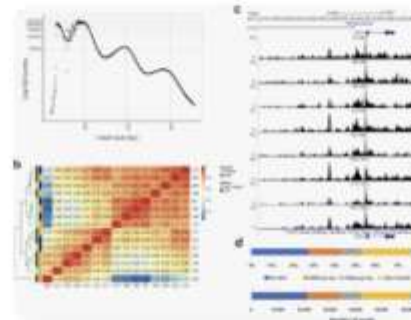
[Compare insights](#)



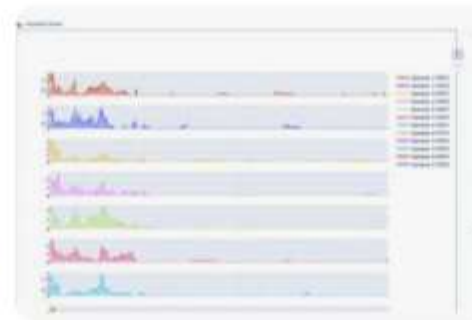
Galaxy Training!
Hands-on: ATAC-Seq ...



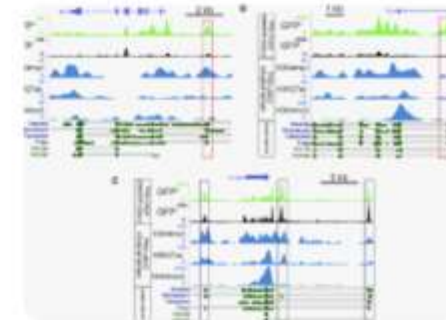
seandavi.github.io
ATAC-Seq with Biocondu...



Nature
open chromatin in pancreatic isl...



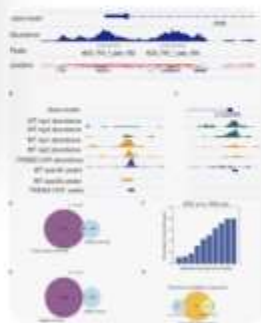
LatchBio
Interactive Tools for ATAC-seq Analysis



ResearchGate
Mapping of ATAC-Seq Reads at Kn...



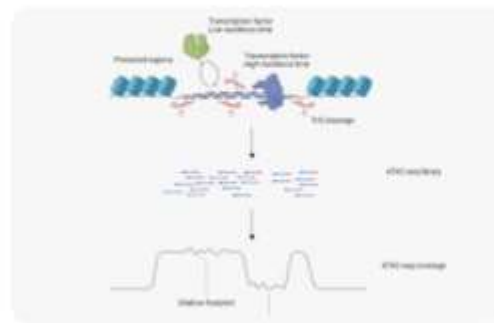
Springer Link
ATAC-seq data analysis | Ge...



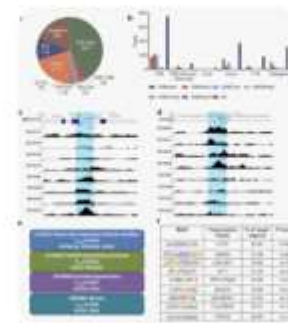
ResearchGate
Visualization of AT...



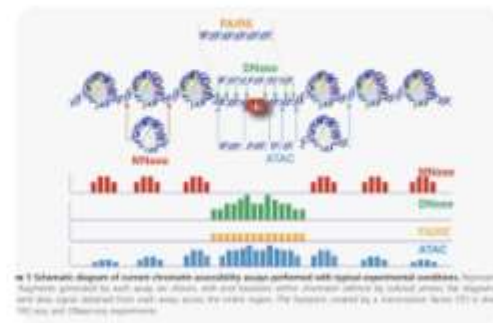
Nature
ATAC-Seq analysis...



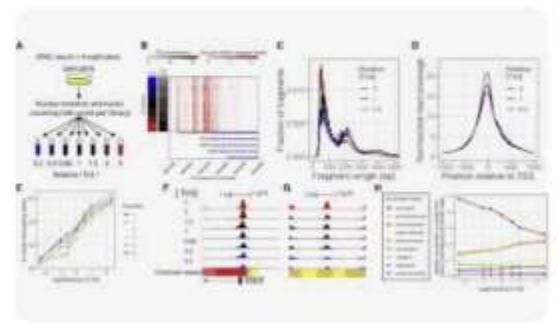
BioRender.com
Digital footprinting with ATAC-seq ...



APEX-BIO
ATAC-seq



Yiwei Niu
ATAC-seq data analysis: from FASTQ t...



Cell Press
ATAC-Seq Data with ataqv: Cell ...

ChIP-seq data snapshot

To investigate the interaction between proteins and DNA

| seqnames | start | end | strand | Symbol | distanceTSS | Group1 | Group2 |
|-----------------|--------------|------------|---------------|---------------|--------------------|---------------|---------------|
| chr1 | 11 | 70 | + | Gene1 | 5000 | 11 | 21 |
| chr1 | 200 | 400 | - | Gene1 | 5000 | 10 | 100 |
| chr1 | 100 | 290 | + | Gene3 | 2000 | 200 | 1000 |
| chr2 | 100 | 500 | - | Gene4 | 3000 | 400 | 1300 |
| chr2 | 50 | 100 | + | Gene5 | 20000 | 20 | 120 |
| chr3 | 40 | 200 | - | Gene6 | 40000 | 540 | 40 |
| chr4 | 5 | 150 | - | Gene7 | 150 | 1500 | 15 |

How can you visualize the ChIP-seq data?



chip seq visualization



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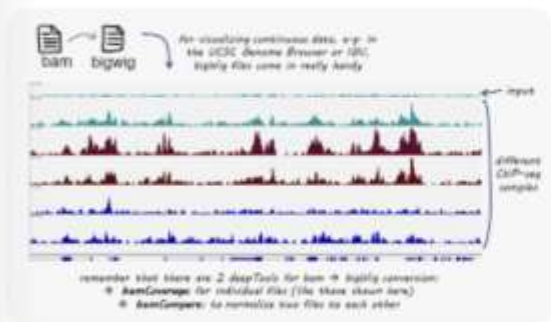
Tools ▾

Saves

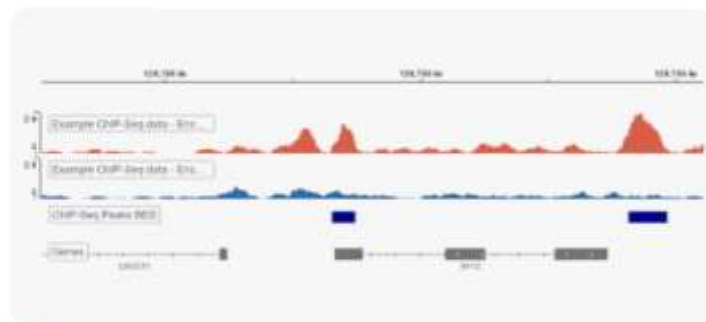


See detailed insights & Compare multiple related Papers for : **"chip seq visualization"**

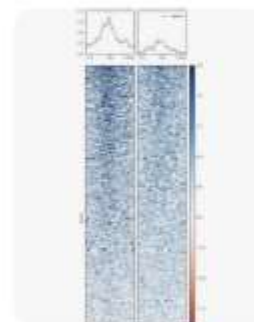
Compare insights



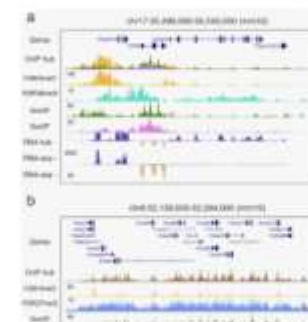
GitHub Pages
Visualization of peaks | Introduction ...



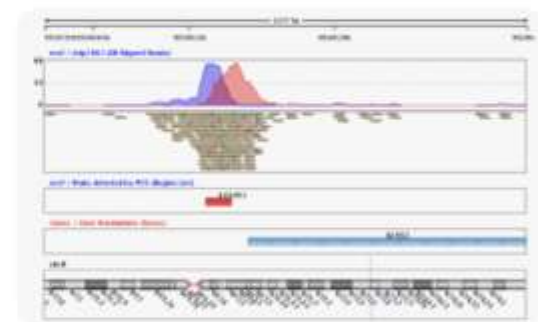
Basepair
ChIP-Seq Analysis Tutorial - Basepair



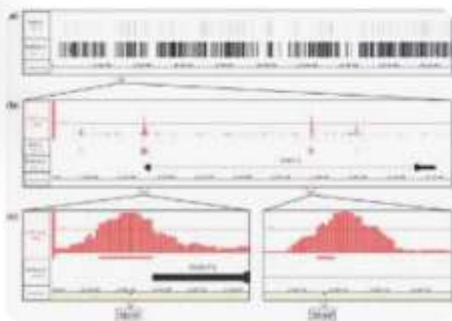
GitHub Pages
Visualization of pe...



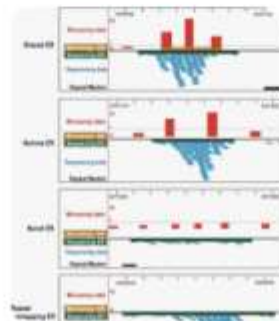
Nature
Productive visualizatio...



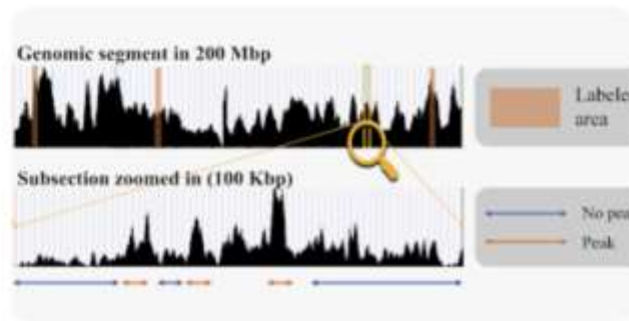
NGS Strand NGS
ChIP-Seq | Strand NGS



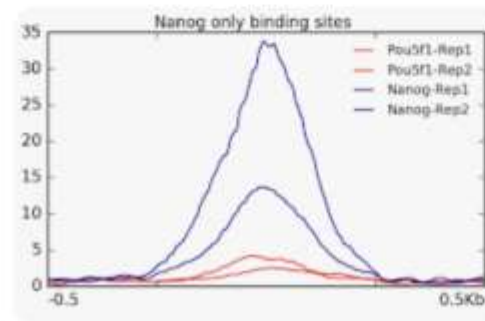
ResearchGate
Visualizing ChIP-Seq data. (a) MAC...



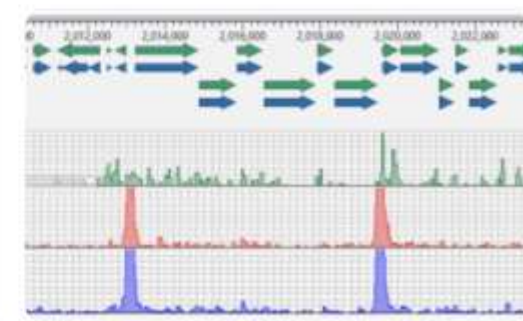
ResearchGate
ChIP-seq data for H...



Nature
CNN-Peaks: ChIP-Seq peak detection ...



GitHub Pages
Visualization of peaks | Introduction ...



dnastar
ChIP-Seq Data Analysis Workflow | DNA...

WGBS data snapshot

To determine the methylation state of the genome.

| seqnames | start | end | strand | Symbol | distanceTSS | Group1 | Group2 |
|----------|-------|-----|--------|--------|-------------|--------|--------|
| chr1 | 1 | 1 | + | Gene1 | 5000 | 1.0 | 0.0 |
| chr1 | 100 | 100 | - | Gene1 | 5000 | 0.0 | 0.0 |
| chr1 | 200 | 200 | + | Gene3 | 2000 | 0.7 | 1.0 |
| chr2 | 300 | 300 | - | Gene4 | 3000 | 0.4 | 0.3 |
| chr2 | 20 | 20 | + | Gene5 | 20000 | 0.2 | 0.1 |
| chr3 | 40 | 40 | - | Gene6 | 40000 | 1.0 | 1.0 |
| chr4 | 15 | 15 | - | Gene7 | 150 | 0.0 | 1.0 |

How can you visualize the WGBS data?



wgbs seq visualization



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Tools ▾

Saves



Single cell



Igv



Zymo



Tumor



Zymo seq



Genome wide



Rna seq data



Pipeline



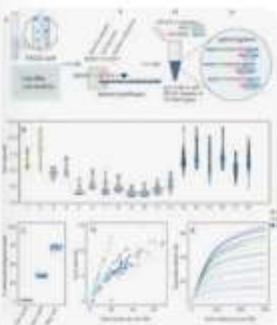
Zymo research



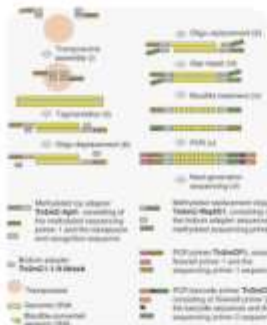
Methylated n

See detailed insights & Compare multiple related Papers for : **"wgbs seq visualization"**

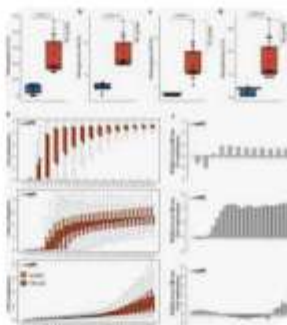
Compare insights



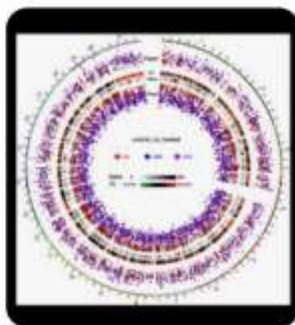
Nature
single cell WGBS lib...



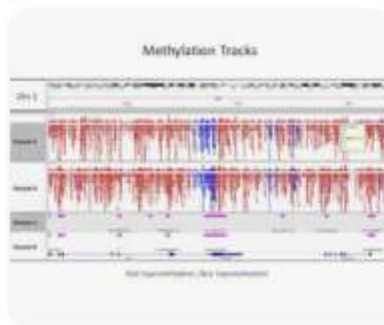
ResearchGate
T-WGBS library pre...



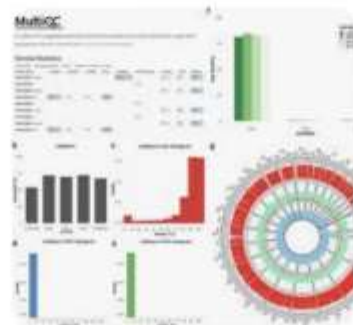
ResearchGate
methylation levels be...



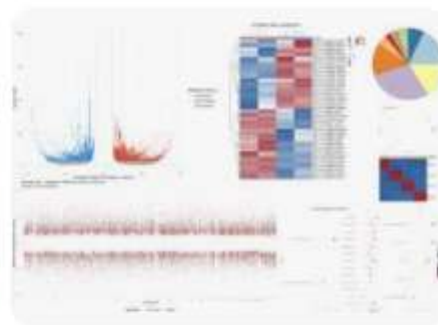
Novogene
Whole Genome Bisulfi...



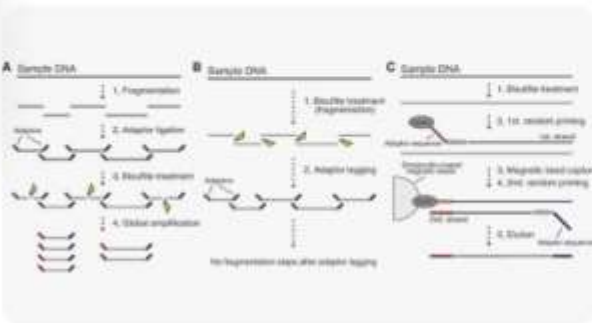
EpigenTek
Whole Genome Bisulfite Sequ...



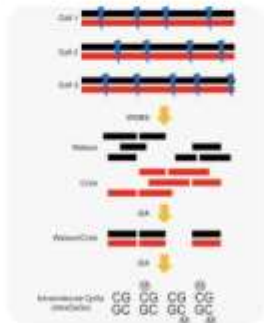
Springer Link
whole-genome bisulfite se...



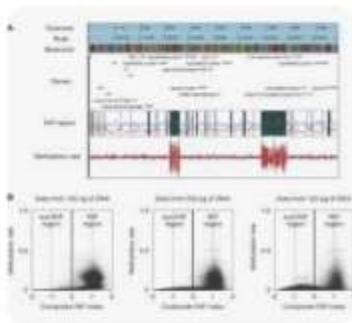
NGS Learning Hub
How To Analyze DNA Methylation ...



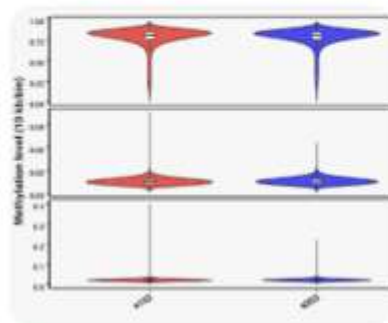
ResearchGate
WGBS and PBAT. (A) Schematic of the ...



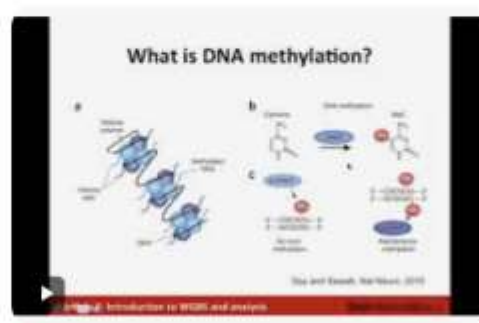
Nature
Resolution of the D...



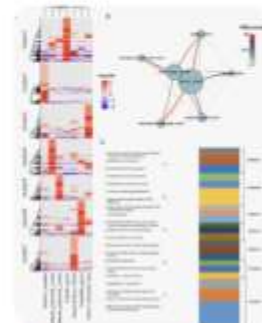
ResearchGate
WGBS of *N. crassa* by PB...



Novogene
Whole Genome Bisulfite Sequ...



YouTube
Introduction to WGBS and Analysis - Y...



Frontiers
Gene Expression a...

RNA-seq data snapshot

To analyze expression across the transcriptome.

| Gene | Transcript | seqnames | start | end | Group1 | Group2 |
|-------|-------------|----------|-------|-------|--------|--------|
| Gene1 | Transcript1 | chr1 | 1 | 1000 | 100 | 0 |
| Gene1 | Transcript2 | chr1 | 100 | 12000 | 0 | 110 |
| Gene3 | Transcript1 | chr1 | 200 | 500 | 70 | 1000 |
| Gene4 | Transcript1 | chr2 | 300 | 900 | 400 | 30 |
| Gene5 | Transcript1 | chr2 | 20 | 2000 | 20 | 1 |
| Gene6 | Transcript1 | chr3 | 40 | 4000 | 1 | 0 |
| Gene7 | Transcript1 | chr4 | 15 | 150 | 0 | 0 |

How can you visualize the RNA-seq data?



rna seq visualization



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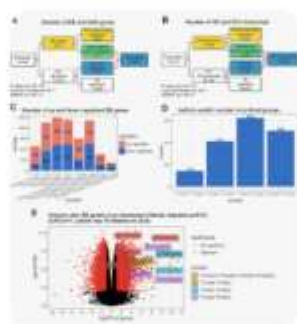


See detailed insights & Compare multiple related Papers for : "rna seq visualization"

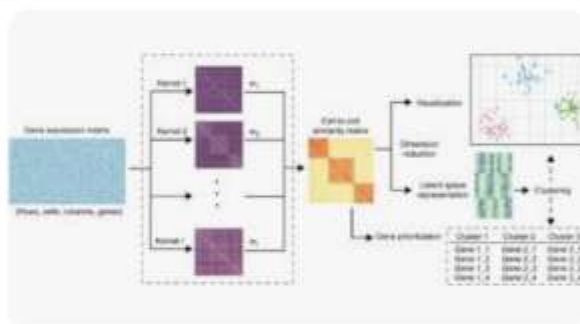
Compare insights



Posit Community
rnaseqDRAMA - RNAseq data ...



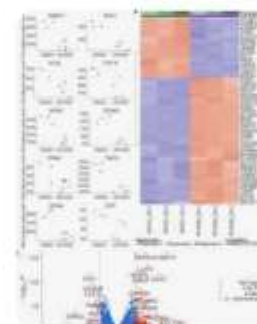
ResearchGate
visualization outputs f...



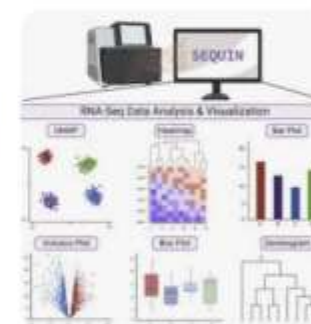
Nature
analysis of single-cell RNA-seq data ...



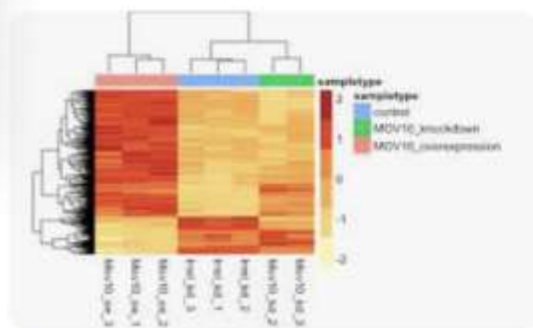
Elucidata
Bulk RNA-seq Data Visualization Tools



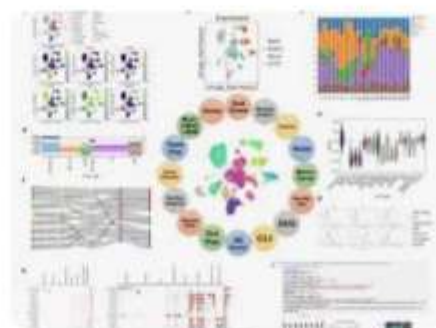
Springer
RNA-seq data | B...



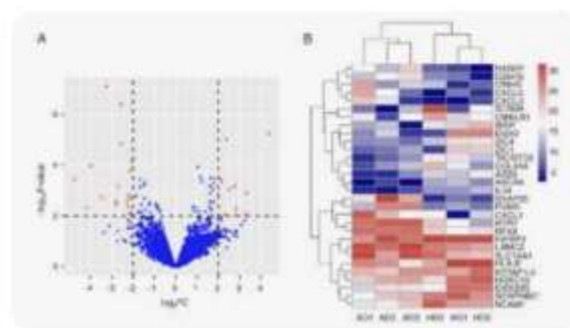
ScienceDirect.com
RNA-seq data ...



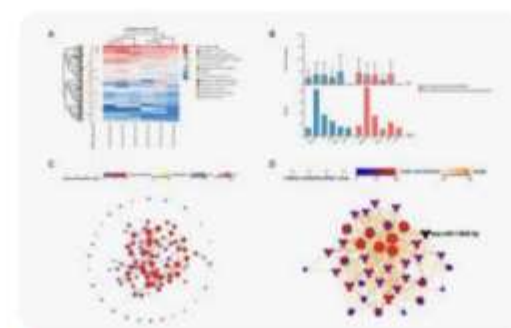
GitHub Pages
RNA-seq visualizations | Training-modules



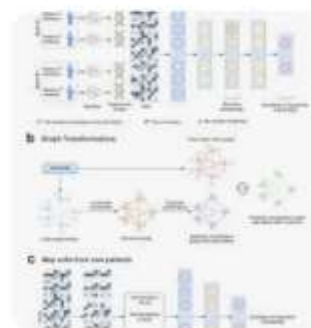
BioRx
BxGenomics - RNA-Seq data anal...



ResearchGate
Visualization of DEGs between AD-MSCs ...



RNA-Seq Blog
Intuitive RNA Data Visualization ...



Nature
single-cell RNA-Seq pro...

How can you visualize ATAC-seq, ChIP-seq, WGBS, and RNA-seq data together?



atac seq, chip seq, wgbs, rna seq: multiomics visualization



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Saves



Hi c



Epigenetics



Dna methylation



Data



Chromosome



Scrna seq analysis



Epigenomics



Single cell



Scatac seq

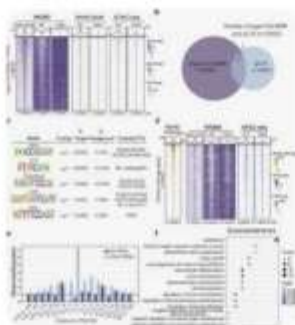


See detailed insights & Compare multiple related Papers for : **“atac seq, chip seq, wgbs, rna seq: multiomics visualization”**

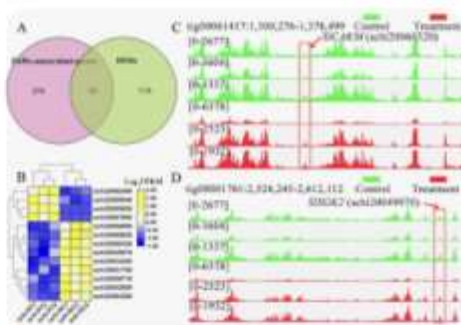
[Compare insights](#)



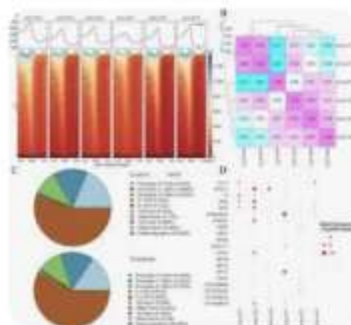
Genevia Technologies
RNA-seq and ChIP-seq data ...



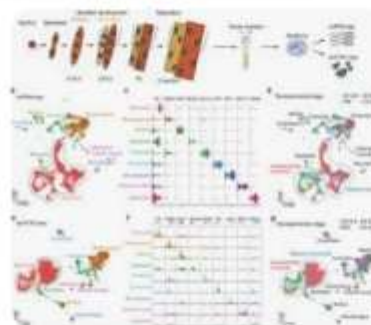
ResearchGate
RNA-seq, WGBS, 5h...



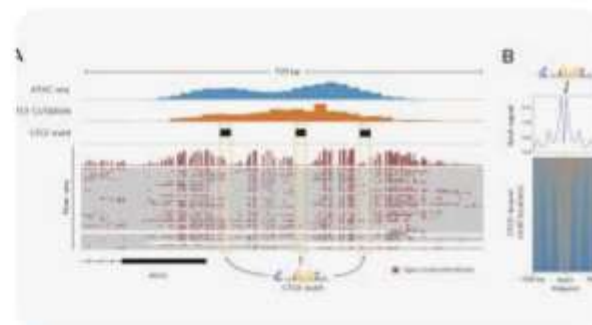
Springer Link
ATAC-seq and RNA-seq ...



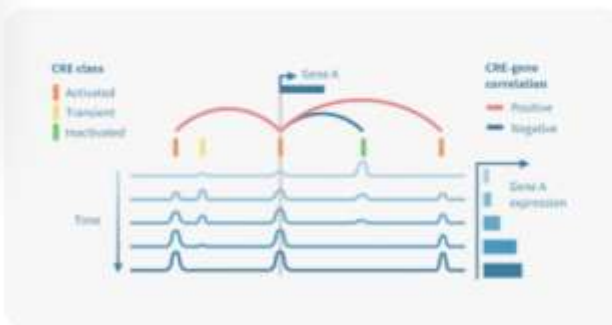
Springer Link
ATAC-seq and RNA-seq ...



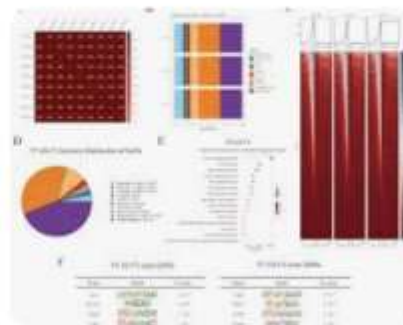
ResearchGate
Multi-omics single nucleus R...



EpiCypher
Fiber-seq 101: A Multiomic Assay That ...



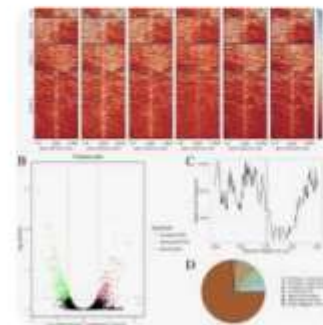
Genevia Technologies
RNA-seq and ChIP-seq data ...



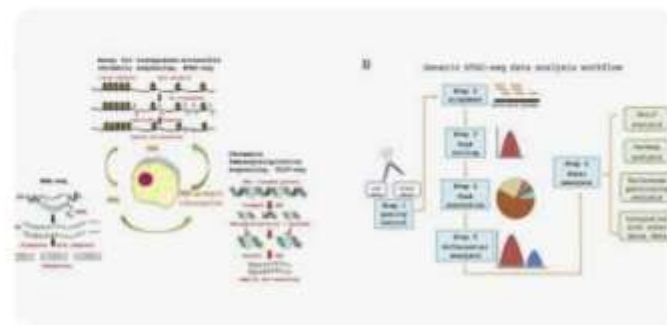
MDPI
ATAC-seq and RNA-seq Analysis...



STAR Protocols - Cell Press
chromatin remodeling ...



Springer Link
ATAC-seq and RNA-seq ...

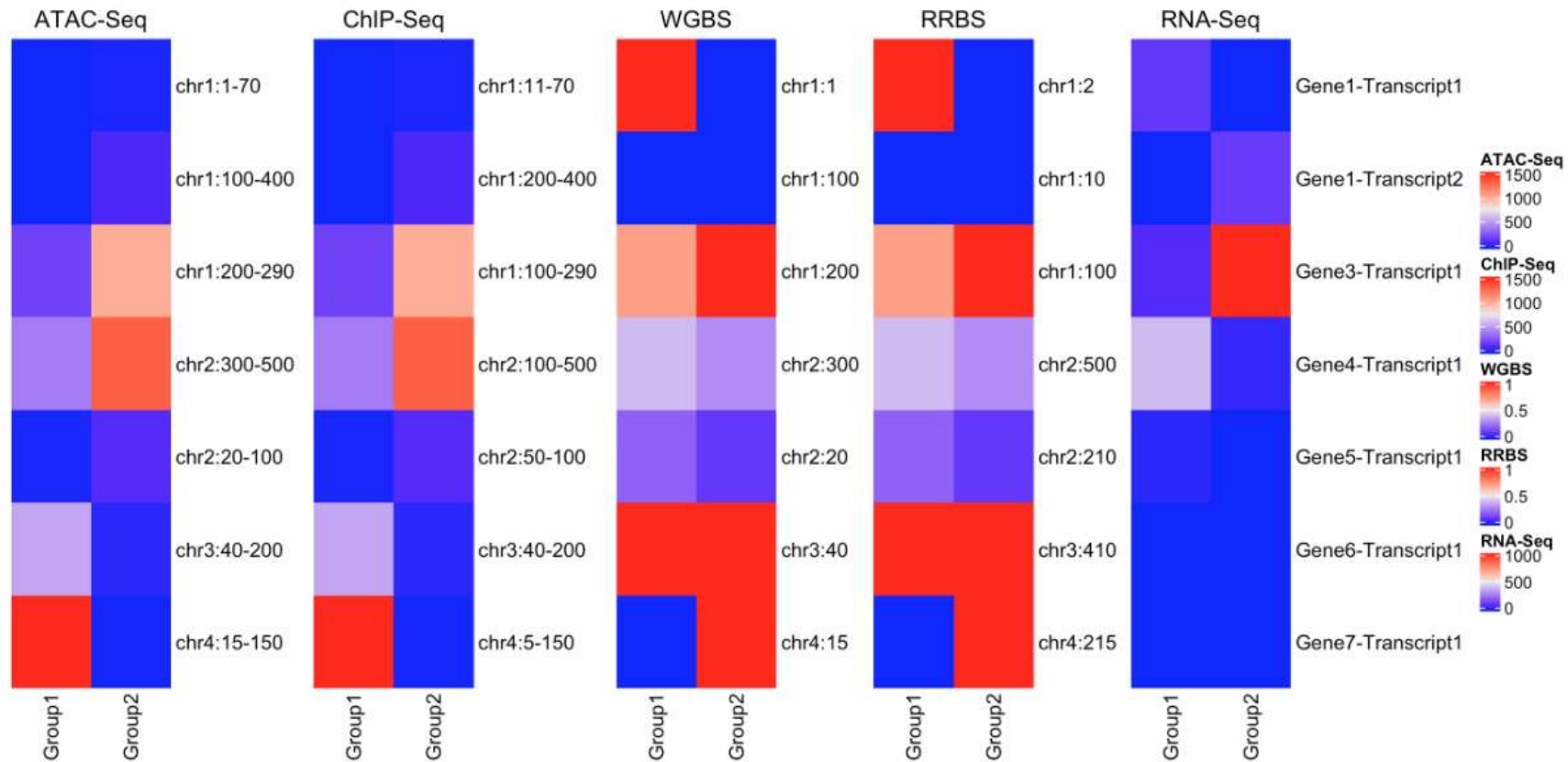


ResearchGate
Principles and workf low of ATAC-seq ...

What is the best way to visualize these data together?

These tables have 100's of 1000's of rows

Heatmaps?



How to properly integrate these data?

Let's say, we want to look around 200bp of TSS!

**TSS
(target)**

| | seqnames | position | strand |
|--------|----------|----------|--------|
| Gene_1 | chr21 | 13 | + |
| Gene_2 | chr21 | 46 | + |
| Gene_3 | chr21 | 78 | + |
| Gene_4 | chr21 | 10 | + |
| Gene_5 | chr21 | 45 | + |

How to properly integrate these data?

Let's say, we want to look around 200bp of TSS!

**TSS
(target)**

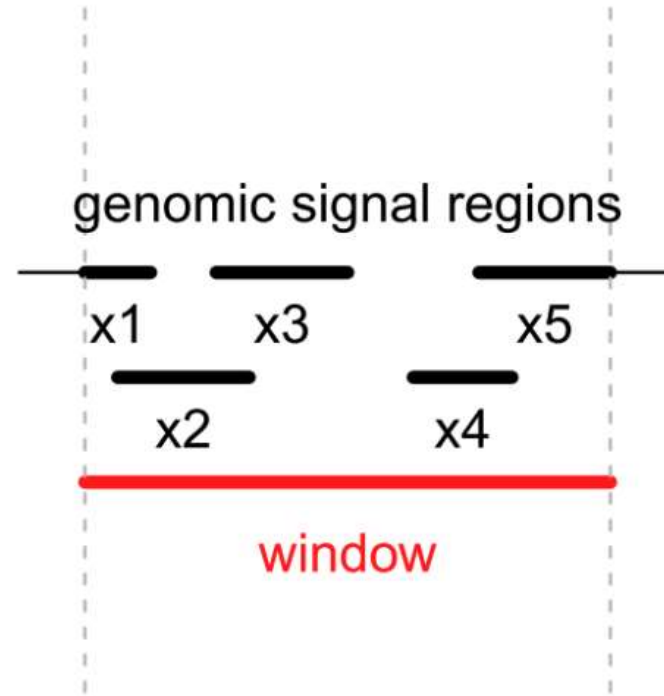
| | seqnames | position | strand |
|--------|----------|----------|--------|
| Gene_1 | chr21 | 13 | + |
| Gene_2 | chr21 | 46 | + |
| Gene_3 | chr21 | 78 | + |
| Gene_4 | chr21 | 10 | + |
| Gene_5 | chr21 | 45 | + |

**ChIP-Seq data
(genomic signal)**

| seqnames | start | end | strand | Group1 |
|----------|-------|-----|--------|--------|
| chr21 | 11 | 70 | + | 11 |
| chr21 | 200 | 400 | - | 10 |
| chr21 | 100 | 290 | + | 200 |
| chr21 | 100 | 500 | - | 400 |
| chr21 | 50 | 100 | + | 20 |

Averaging methods to summarize the signals

Averaging model



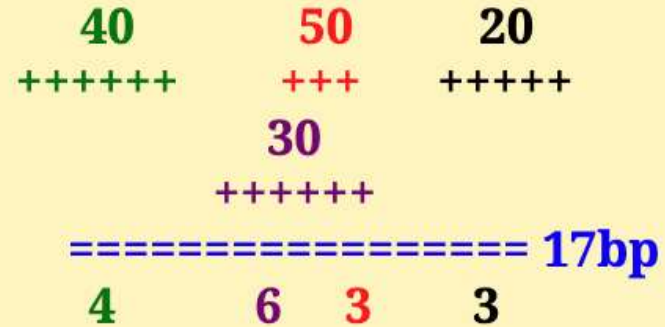
The **red line** represents one window in the target regions or in the flanking regions when normalizing genomic signals to target regions. **Black lines** represent genomic signals that overlap to the given window.

Averaging methods to summarize the signals

absolute

$$v_a = \frac{\sum_{i=1}^n x_i}{n}$$

Calculates the **mean** value from all signal regions regardless of their width.



4bp not overlapping to any region

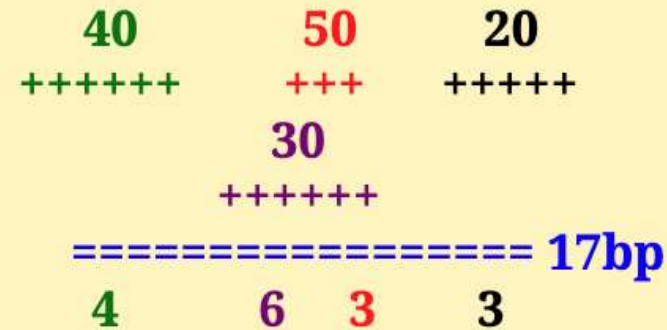
$$v_a = \frac{40 + 30 + 50 + 20}{4}$$

Averaging methods to summarize the signals

weighted

$$v_w = \frac{\sum_{i=1}^n x_i w_i}{\sum_{i=1}^n w_i}$$

Calculates the **mean** value from all signal regions **weighted by the width of their intersections.**



4bp not overlapping to any region

$$v_w = \frac{40 \times 4 + 30 \times 6 + 50 \times 3 + 20 \times 3}{4 + 6 + 3 + 3}$$

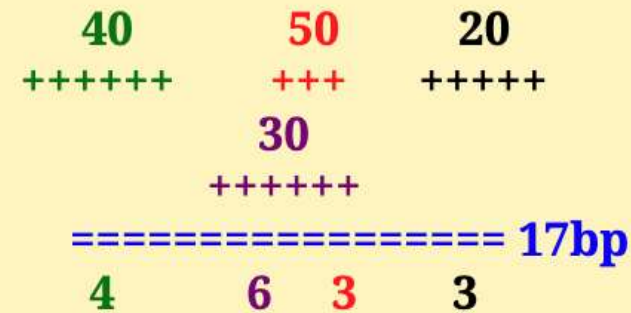
Averaging methods to summarize the signals

WO

$$v_{w0} = \frac{\sum_{i=1}^n x_i w_i}{W + W'}$$

Calculates the **weighted mean** between the intersected and un-intersected parts.

$$(W = \sum_{i=1}^n w_i),$$
$$(W' = \sum_{i=1}^n w'_i)$$



4bp not overlapping to any region

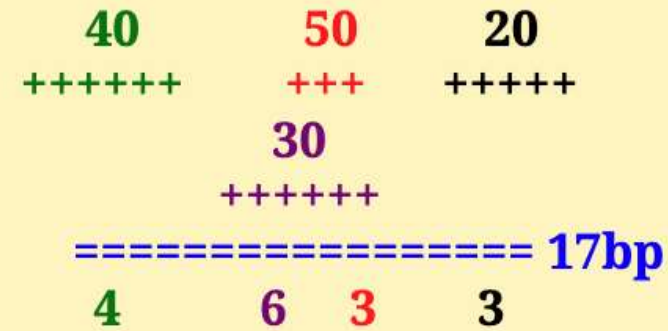
$$v_{w0} = \frac{40 \times 4 + 30 \times 6 + 50 \times 3 + 20 \times 3}{4 + 6 + 3 + 3 + 4}$$

Averaging methods to summarize the signals

coverage

$$v_c = \frac{\sum_i^n x_i w_i}{L}$$

The mean signal averaged by the width of the window. L is the width of the window itself.



4bp not overlapping to any region

$$v_c = \frac{40 \times 4 + 30 \times 6 + 50 \times 3 + 20 \times 3}{17}$$

How to use these methods?

Gu et al. *BMC Genomics* (2018) 19:234
<https://doi.org/10.1186/s12864-018-4625-x>

BMC Genomics

SOFTWARE

Open Access



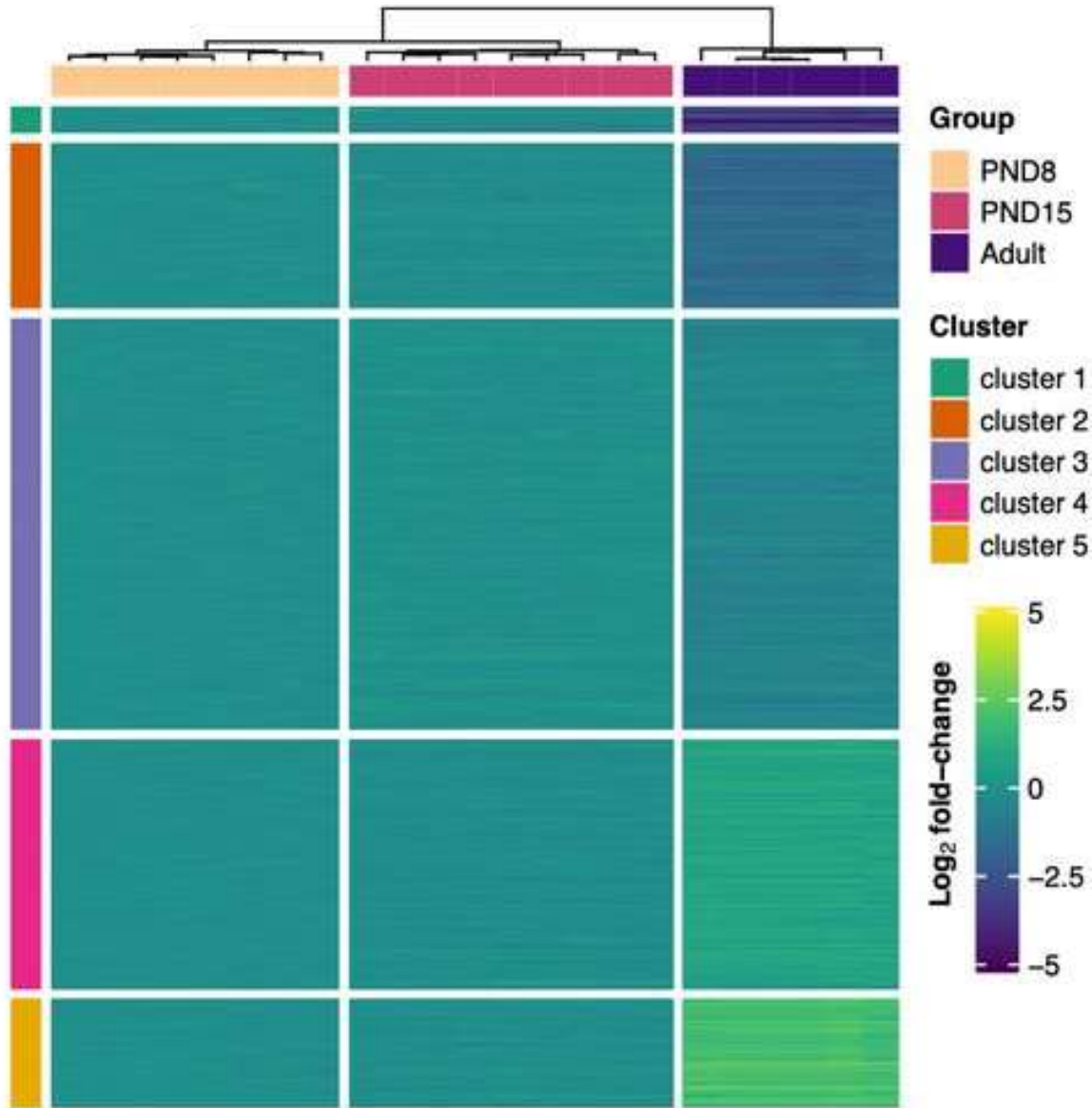
EnrichedHeatmap: an R/Bioconductor package for comprehensive visualization of genomic signal associations

Zuguang Gu^{1,2*}, Roland Eils^{1,2,3}, Matthias Schlesner¹ and Naveed Ishaque^{1,2}

Which method to be used for different data?

| Assay | Signal Representation | Recommended mean_mode | Key Considerations |
|----------|---------------------------|-----------------------|--|
| ATAC-seq | Peaks (binary) | "coverage" | Shows fraction of window covered by peaks. |
| | Coverage (numeric) | "w0" | Averages signal intensity, weighted by overlap. Good for BigWig data. |
| ChIP-seq | Peaks (binary) | "coverage" | Shows fraction of window covered by peaks. |
| | Coverage (numeric) | "w0" | Averages signal intensity, weighted by overlap. Good for BigWig data. Set <code>empty_value = 0</code> (or background). |
| WGBS | CpG methylation (numeric) | "absolute" | <p>Averages methylation values of individual CpG sites within the window. Crucial to set <code>value_column</code> .</p> <p>Highly recommend <code>smooth = TRUE</code> and <code>empty_value = NA</code> for better visualization due to sparse CpG distribution.</p> |

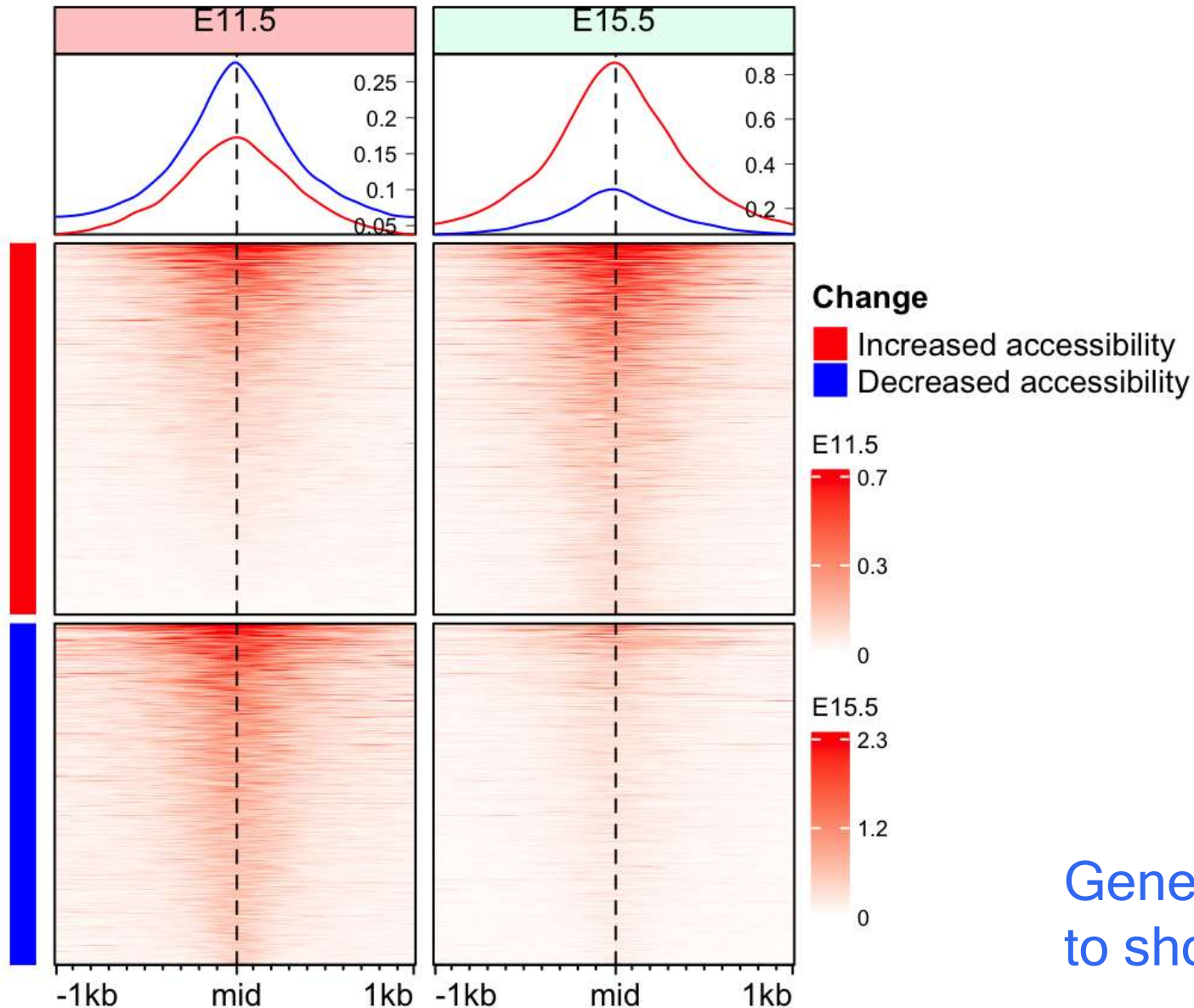
Understanding Heatmap



Heatmap

- Matrix
- Color
- Rows
- Rows annotation
- Columns
- Columns annotation
- Color scale
- Clustering
- Rows and columns order

Understanding EnrichedHeatmap

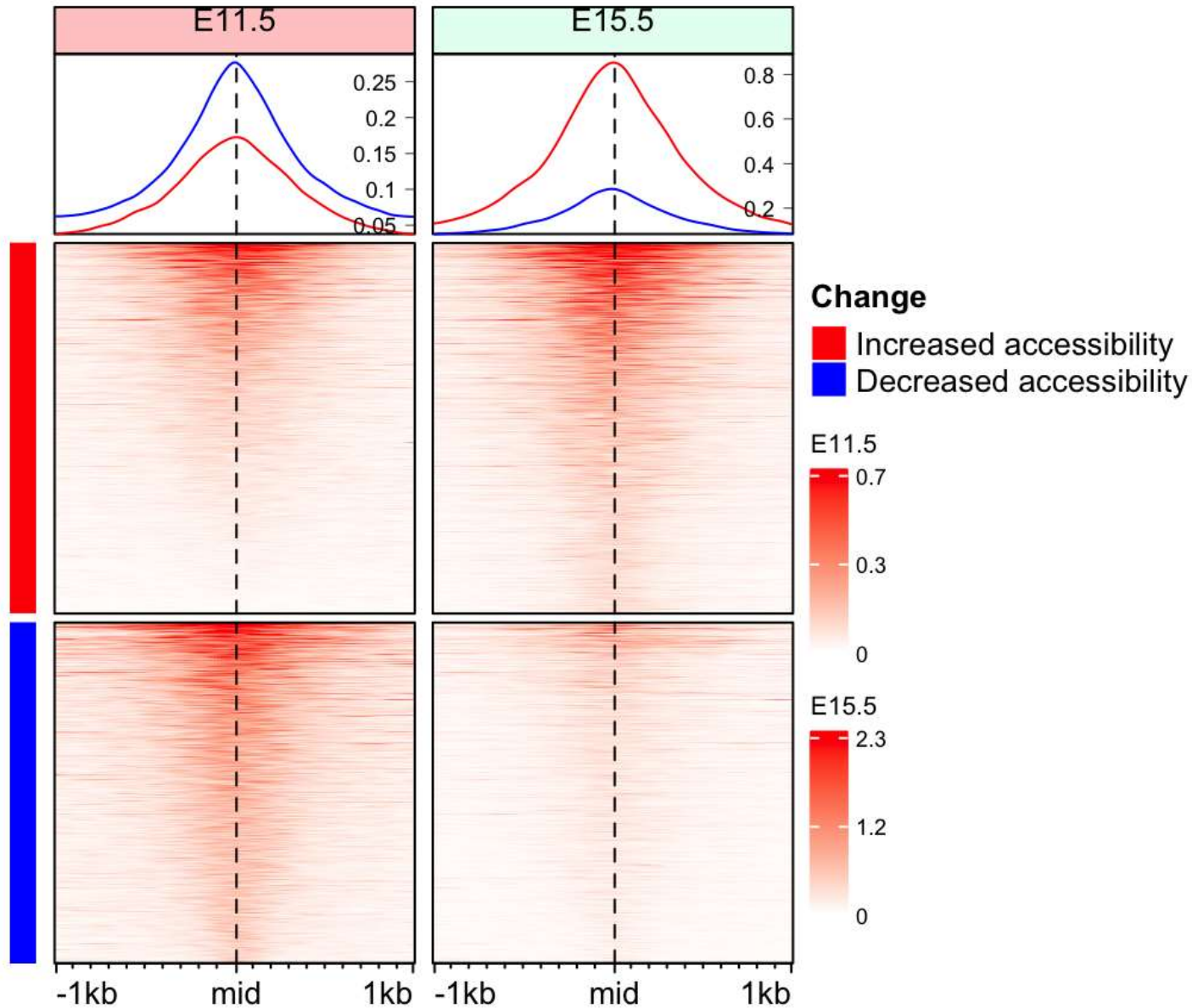


EnrichedHeatmap

- Matrix
- Color
- Rows
- Rows annotation
- Profile plot
- Columns title
- Color scale
- Rows order
- Axis

Generally, replicates are merged into one to show average differences

Understanding EnrichedHeatmap

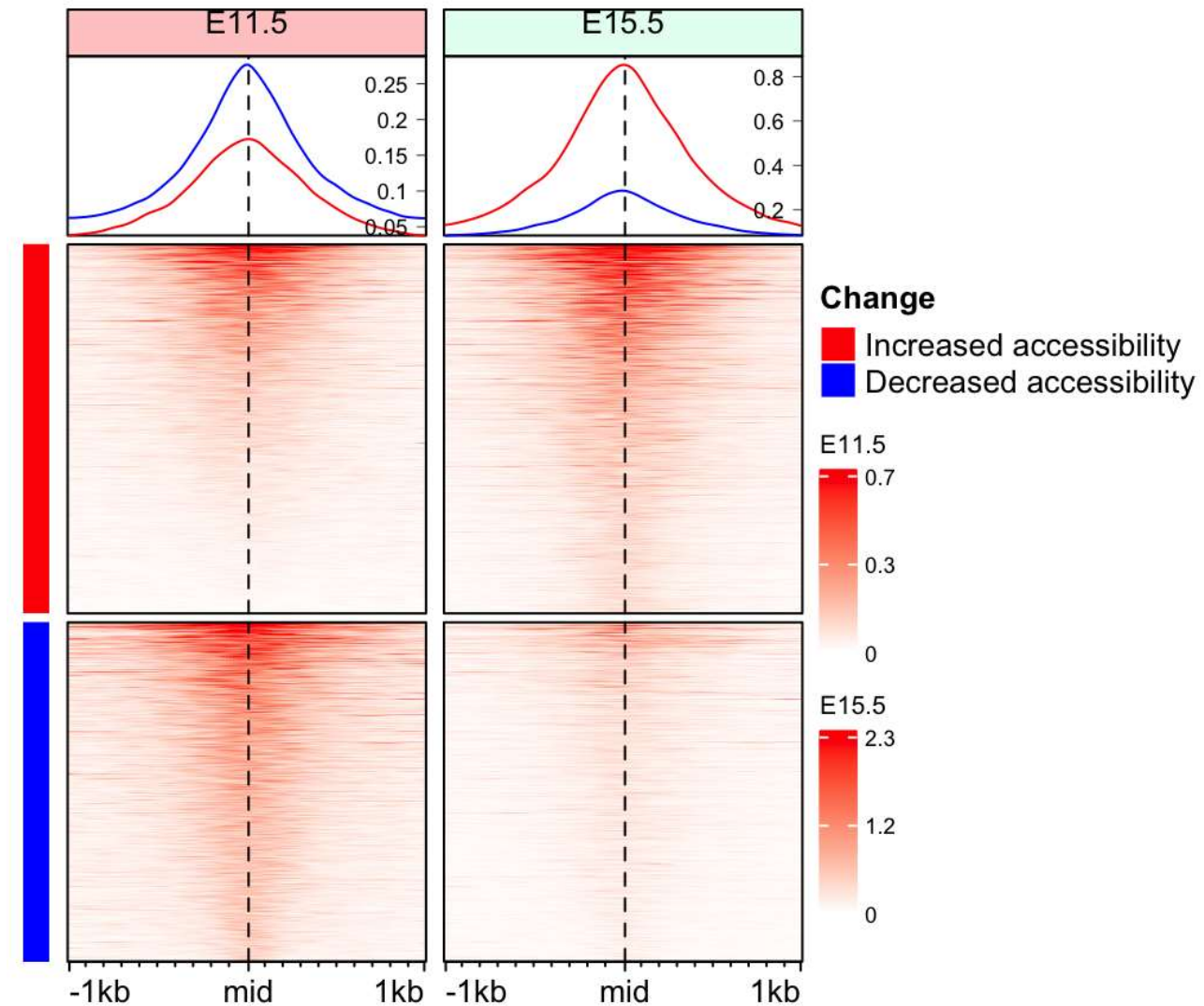
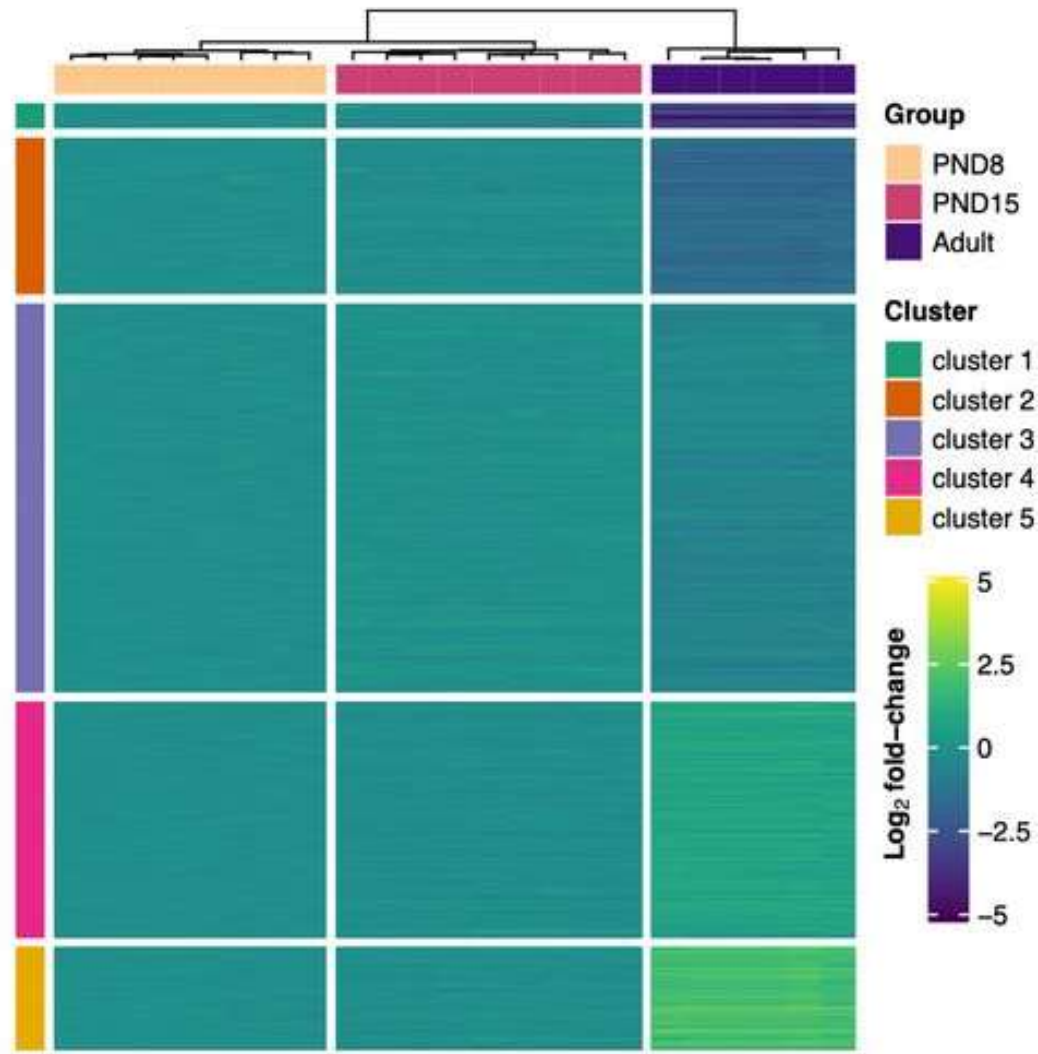


E15.5

- Color scale: 0 - 2.3
- Profile plot scale: 0-0.8

Why?

Best way to represent complex data. Other ways?



Exercise 2 & 3

