

#2.1: Scripting and data preparation

SRA-toolkit

Scripting

Downloading source files

Access the slides and files here:

https://github.com/j-berg/bioinformatics_bootcamp

Downloading publicly available data

Any published NIH-funding sequencing datasets *should* appear here

NCBI Resources How To jordan.berg@biochem.utah.edu My NCBI Sign Out

GEO Home Documentation Query & Browse Email GEO My GEO Submissions

COVID-19 is an emerging, rapidly evolving situation.
Get the latest public health information from CDC: <https://www.coronavirus.gov>.
Get the latest research from NIH: <https://www.nih.gov/coronavirus>.
Find NCBI SARS-CoV-2 literature, sequence, and clinical content: <https://www.ncbi.nlm.nih.gov/sars-cov-2/>.

Gene Expression Omnibus

GEO is a public functional genomics data repository supporting MIAME-compliant data submissions. Array- and sequence-based data are accepted. Tools are provided to help users query and download experiments and curated gene expression profiles.

Keyword or GEO Accession

Getting Started


- Overview
- FAQ
- About GEO DataSets
- About GEO Profiles
- About GEO2R Analysis
- How to Construct a Query
- How to Download Data

Tools

- Search for Studies at GEO DataSets
- Search for Gene Expression at GEO Profiles
- Search GEO Documentation
- Analyze a Study with GEO2R
- Studies with Genome Data Viewer Tracks
- Programmatic Access
- FTP Site

Browse Content

Repository Browser

DataSets:	4348
Series: 	130720
Platforms:	20986
Samples:	3625449

Information for Submitters

My GEO Submissions	Submission Guidelines	MIAME Standards
My GEO Profile	Update Guidelines	Citing and Linking to GEO
		Guidelines for Reviewers
		GEO Publications

Downloading publicly available data

- SRA-toolkit

- Download and unpackage

```
$ curl -OL http://ftp-trace.ncbi.nlm.nih.gov/sra/sdk/current/sratoolkit.current-centos\_linux64.tar.gz
```

```
$ tar -zxvf sratoolkit.current-centos\_linux64.tar.gz
```

- Rename

```
$ mv sratoolkit.2.10.7-centos_linux64 sratoolkit
```

- Make SRA-toolkit findable to you anywhere in supercomputer

```
$ echo 'export PATH="/uufs/chpc.utah.edu/common/home/u0690617/sratoolkit/bin:$PATH"' >> ~/.bashrc
```

Figure S7A-B). Transcription profile data are available in supplementary material (see Additional file 1: Dataset S1) and from the Gene Expression Omnibus (accession no. GSE54825) [93]. All annotations were derived from the SGD gene association file [94].

Samples (6) [More...](#)
GSM1324496 JCYL001B
GSM1324497 JCYL002B
GSM1324498 JCYL003B

Relations
BioProject [PRJNA237759](#)
SRA [SRP037533](#)

Download family	Format
SOFT formatted family file(s)	SOFT ?
MINiML formatted family file(s)	MINiML ?
Series Matrix File(s)	TXT ?

Supplementary file	Size	Download	File type/resource
GSE54825_Cellobiase_versus_Glucose.xlsx.gz	708.7 Kb	(ftp) (http)	XLSX

[SRA Run Selector](#) [?](#)
Processed data are available on Series record
Raw data are available in SRA

Accession

Common Fields

BioProject	PRJNA237759
Consent	PUBLIC
Assay Type	RNA-Seq
AvgSpotLen	50
Center Name	GEO
DATASTORE filetype	SRA
DATASTORE provider	GS, NCBI, S3
DATASTORE region	gs.US, ncbi.public, s3.us-east-1
growth_condition	Anaerobic

Select

	Runs	Bytes	Bases	Download
Total	6	7.44 Gb	11.93 G	<div>Metadata or Accession List</div>
Selected	0	0	0	<div>Metadata or Accession List or JWT Cart</div>

Download a file by SRR accessor

```
[(base) [u      @notchpeak1 ~]$ prefetch SRR1166442

2020-06-07T13:26:44 prefetch.2.9.3: 1) Downloading 'SRR1166442'...
2020-06-07T13:26:44 prefetch.2.9.3:  Downloading via https...
2020-06-07T13:28:12 prefetch.2.9.3: 1) 'SRR1166442' was downloaded successfully
[(base) [u      @notchpeak1 ~]$ fastq-dump --outdir ~/ --split-files /uufs/chpc.utah.edu/common/home/
    /ncbi/public/sra/SRR1166442.sra
Read 40585197 spots for /uufs/chpc.utah.edu/common/home/u      /ncbi/public/sra/SRR1166442.sra
Written 40585197 spots for /uufs/chpc.utah.edu/common/home/u      /ncbi/public/sra/SRR1166442.sra
```

Writing your first bash script

```
$ vim download_seqs.sh
```

<-- let's write a new bash script (.sh)

Commands:

- You will start in viewer mode
- Tap “d” twice = delete a line
- Arrow keys to move cursor
- Tap “i” to enter editor mode
- Write your code
- Press escape to exit editor mode
- Type “:wq” to save (write) and quit
- Type “:q” to quit without saving
- If you made changes and want to quit without saving, you will need to use “:q!”

Downloading sequencing files

\$ vim download_seq.sh

Press “i”

```
SRR_IDS=(SRR1166442 SRR1166443 SRR1166444 SRR1166445 SRR1166446 SRR1166447)
OUTPUT=~/.seq_files
PRE_LOC=~/.ncbi/public/sra

mkdir $OUTPUT
for X in ${SRR_IDS[@]}; do prefetch ${X}; done
for X in ${SRR_IDS[@]}; do fastq-dump --outdir $OUTPUT ${X} --split-files $PRE_LOC/${X}.sra; done
```

Press Escape + “wq”, then Enter

Downloading sequencing files

```
(base) [u0690617@notchpeak1 ~]$ bash download_seq.sh

2020-06-07T14:33:11 prefetch.2.9.3: 1) Downloading 'SRR1166442'...
2020-06-07T14:33:11 prefetch.2.9.3: Downloading via https...
2020-06-07T14:34:33 prefetch.2.9.3: 1) 'SRR1166442' was downloaded successfully

2020-06-07T14:34:35 prefetch.2.9.3: 1) Downloading 'SRR1166443'...
2020-06-07T14:34:35 prefetch.2.9.3: Downloading via https...
2020-06-07T14:36:06 prefetch.2.9.3: 1) 'SRR1166443' was downloaded successfully

2020-06-07T14:36:10 prefetch.2.9.3: 1) Downloading 'SRR1166444'...
2020-06-07T14:36:10 prefetch.2.9.3: Downloading via https...
2020-06-07T14:37:16 prefetch.2.9.3: 1) 'SRR1166444' was downloaded successfully

2020-06-07T14:37:18 prefetch.2.9.3: 1) Downloading 'SRR1166445'...
2020-06-07T14:37:18 prefetch.2.9.3: Downloading via https...
```

Downloading reference files

The screenshot displays the Ensembl genome browser interface for *Saccharomyces cerevisiae* (R64-1-1). The browser address bar shows `uswest.ensembl.org/Saccharomyces_cerevisiae/info/index`. The Ensembl logo and navigation links (BLAST/BLAT, VEP, Tools, BioMart, Downloads, Help & Docs, Blog) are visible at the top. A search bar contains the text "Search *Saccharomyces cerevisiae*...". Below the search bar, the text "e.g. VII:786054-786920 or s02-316976 or alcohol dehydrogenase" is shown.

The main content area is divided into several sections:

- Search *Saccharomyces cerevisiae***: A search bar with a dropdown menu set to "Search all categories" and a "Go" button. Below the search bar, the text "e.g. VII:786054-786920 or s02-316976 or alcohol dehydrogenase" is displayed.
- Genome assembly: R64-1-1 (GCA_000146045.2)**: A section with links for "More information and statistics", "Download DNA sequence (FASTA)", "Convert your data to R64-1-1 coordinates", and "Display your data in Ensembl". It also includes a dropdown menu for "Other assemblies" set to "EF4 (Ensembl release 67)" and a "Go" button. To the right, there are icons for "View karyotype" and "Example region".
- Gene annotation**: A section with a link for "More about this genebuild". It lists "What can I find?" as "Protein-coding and non-coding genes, splice variants, cDNA and protein sequences, non-coding RNAs." Below this, there are links for "Download FASTA files for genes, cDNAs, ncRNA, protein" and "Download GTF or GFF3 files for genes, cDNAs, ncRNA, protein". To the right, there are icons for "Example gene" and "Example transcript".
- Comparative genomics**: A section with a link for "More about comparative analysis". It lists "What can I find?" as "Homologues, gene trees, and whole genome alignments across multiple species." Below this, there is a link for "Download alignments (EMF)". To the right, there is an icon for "Example gene tree".
- Regulation**: A section with a link for "More about the Ensembl microarray annotation strategy". It lists "What can I find?" as "Microarray annotations."
- Variation**: A section with a link for "More about variation in Ensembl". It lists "What can I find?" as "Short sequence variants". Below this, there is a link for "Download all variants (GVF)" and a link for "Variant Effect Predictor" with the "VeP" logo. To the right, there is an icon for "Example variant" showing a sequence alignment with a variant.

Downloading reference files

\$ vim download_refs.sh

Press “i”

```
# Set variables
OUTPUT=~/reference_yeast
GTF_URL=ftp://ftp.ensembl.org/pub/release-100/gtf/saccharomyces_cerevisiae/Saccharomyces_cerevisiae.R64-1-1.100.gtf.gz
FASTA_PATH_URL=ftp://ftp.ensembl.org/pub/release-100/fasta/saccharomyces_cerevisiae/dna
CHR=(I II III IV V VI VII VIII IX X XI XII XIII XIV XV XVI)

# Make output and navigate into folder
mkdir $OUTPUT
cd $OUTPUT

# Download GTF
curl -OL $GTF_URL

# Download all Chromosome FASTA files
for X in ${CHR[@]}; do curl -OL $FASTA_PATH_URL/Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.${X}.fa.gz; done

# Decompress all reference files and return to home directory
gzip -d *.gz
cd ~
```

Press Escape + “wq”, then Enter

Downloading reference files

```
(base) [u0690617@notchpeak1 ~]$ bash download_refs.sh
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 539k 100 539k  0     0 143k    0  0:00:03  0:00:03 --:--:-- 143k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 71530 100 71530  0     0 32662    0  0:00:02  0:00:02 --:--:-- 32677
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 248k 100 248k  0     0 99k     0  0:00:02  0:00:02 --:--:-- 99k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 99014 100 99014  0     0 45108    0  0:00:02  0:00:02 --:--:-- 45108
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 464k 100 464k  0     0 169k    0  0:00:02  0:00:02 --:--:-- 169k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 176k 100 176k  0     0 76418    0  0:00:02  0:00:02 --:--:-- 76451
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 84644 100 84644  0     0 38509    0  0:00:02  0:00:02 --:--:-- 38492
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 332k 100 332k  0     0 128k    0  0:00:02  0:00:02 --:--:-- 128k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 171k 100 171k  0     0 74883    0  0:00:02  0:00:02 --:--:-- 74883
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 134k 100 134k  0     0 58845    0  0:00:02  0:00:02 --:--:-- 58845
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 226k 100 226k  0     0 93451    0  0:00:02  0:00:02 --:--:-- 93451
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 203k 100 203k  0     0 89049    0  0:00:02  0:00:02 --:--:-- 89087
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 323k 100 323k  0     0 132k    0  0:00:02  0:00:02 --:--:-- 132k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 281k 100 281k  0     0 115k    0  0:00:02  0:00:02 --:--:-- 115k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 239k 100 239k  0     0 99193    0  0:00:02  0:00:02 --:--:-- 99234
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 333k 100 333k  0     0 128k    0  0:00:02  0:00:02 --:--:-- 128k
% Total    % Received % Xferd  Average Speed   Time    Time     Current
           %         %         Dload  Upload  Total    Spent    Left     Speed
100 289k 100 289k  0     0 116k    0  0:00:02  0:00:02 --:--:-- 116k
```



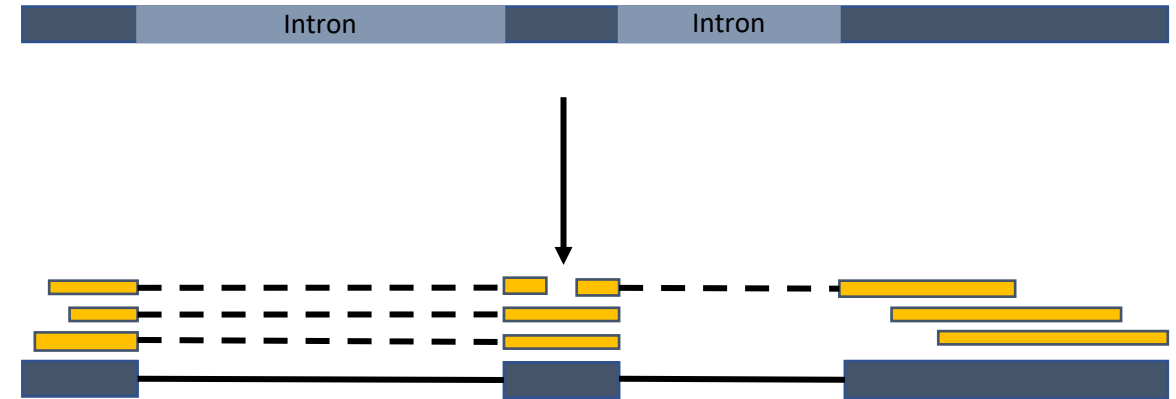
```
(base) [u0690617@notchpeak1 ~]$ cd reference_yeast/
(base) [u0690617@notchpeak1 reference_yeast]$ ls
Saccharomyces_cerevisiae.R64-1-1.100.gtf
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.I.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.II.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.III.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.IV.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.V.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.VI.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.VII.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.VIII.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.X.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.XI.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.XII.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.XIII.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.XIV.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.XV.fa
Saccharomyces_cerevisiae.R64-1-1.dna.chromosome.XVI.fa
```

Genome vs RNA-seq

Genome



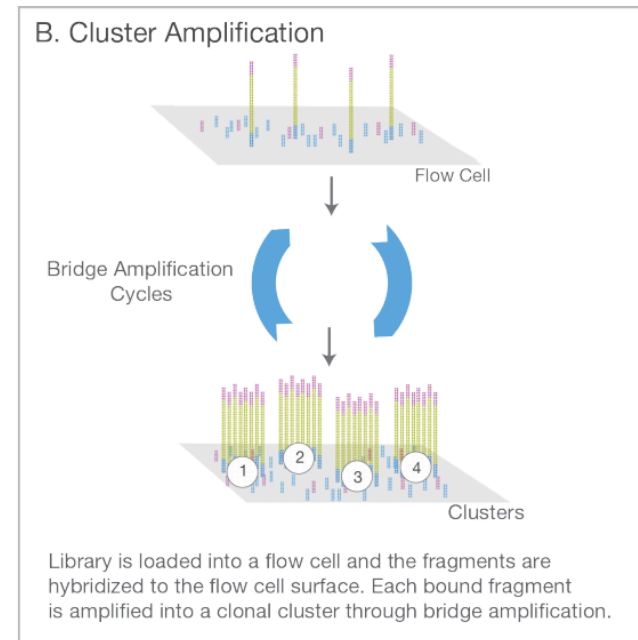
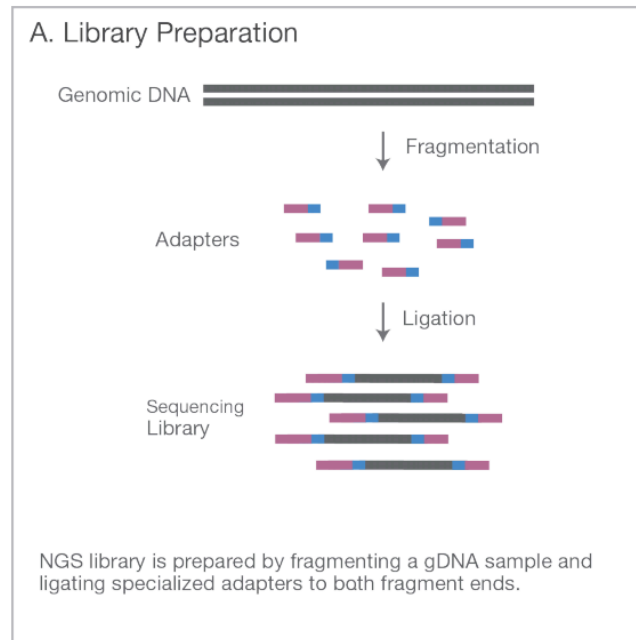
RNA



Different conditions sometimes call for different tools

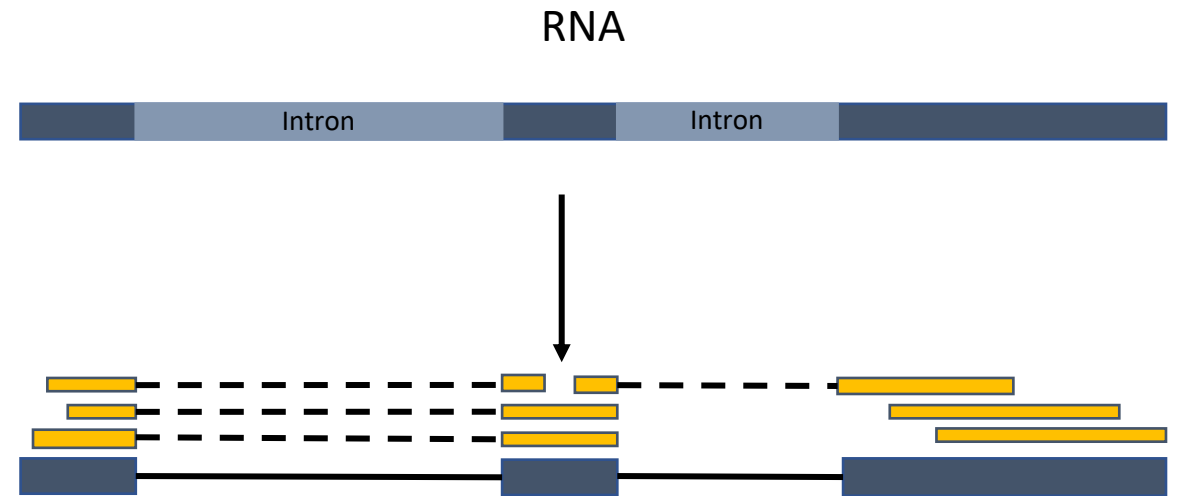
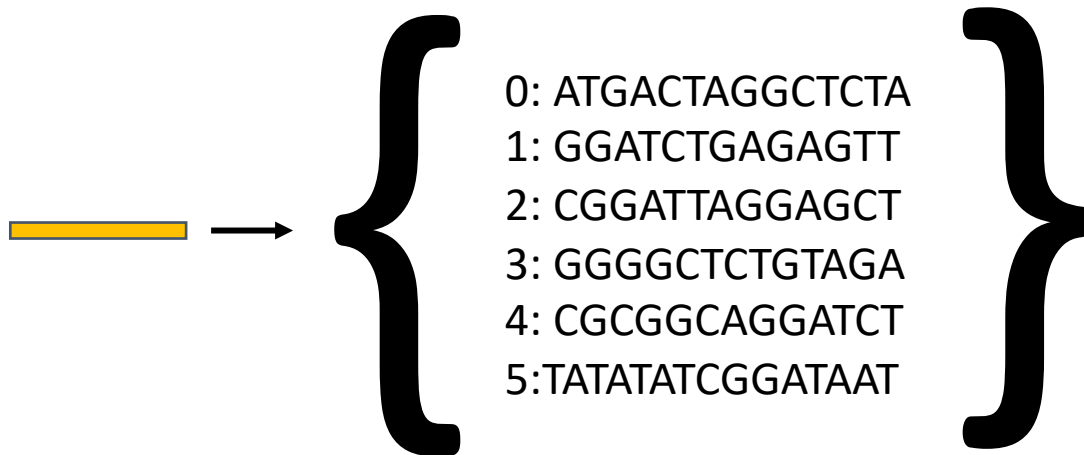
Steps: Pre-processing

- Fastp
 - Remove adapters (will prevent alignment with synthetic sequence)
 - Remove low quality bases and short reads



Steps: Splice-aware Alignment

- STAR
 - Generate a genome index
 - Perform splice-aware alignment of sequencing reads to genome index

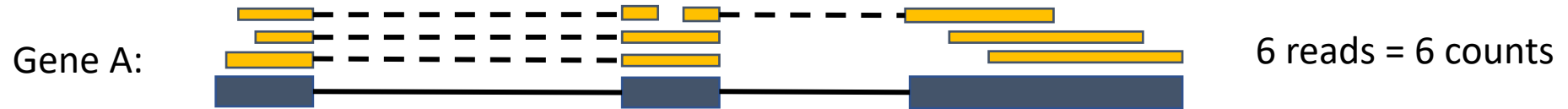


Steps: Post-processing

- Samtools
 - Sort alignments and index

Steps: Quantification

- HTSeq-count
 - Generate read counts for each gene



Steps: Quality Control

- FASTQC
- MultiQC
 - Make sure sequencing library is high-quality and reliable

Downloading required software for RNA-seq

- Make sure channel priority is set

```
$ conda activate class
```

```
$ conda install fastp STAR samtools htseq multiqc fastqc
```

Homework:

- Find an RNA-seq GEO dataset with 8 or fewer total samples
- Create a new folder for the dataset
- Copy the class sequence file download script and modify as needed to download each of the files from the GEO dataset
- Copy one of the files with a new name and decompress the file
- Use the head command to determine the average length of the first 10 reads of this copied file
- Delete the copied file (but do not remove the original downloads)