

**BIO609:** Bash scripting. Bash is a unix shell and command language. It is mostly the default login shell (the shell you work with when you login to a Unix machine).



### Exercise 1: writing and executing a shell script

Try to copy/paste the below simple bash script into a file and execute it. The hello world bash script:

```
#!/bin/bash
echo "Hello World"
```

Copy the above 2 lines and save them to the file "hello.sh". The first line tells the Unix shell to interpret the program. In order to run the program you still need to make the file "executable" (x flag).

Make your file executable by typing:

```
$ chmod +x hello.sh
```

And now you can simply type:

```
$ ./hello.sh
```

Note the "." at the start of the command. This is because the directory where we stored `hello.sh` is not in the system variable `$PATH`.



### Exercise 2: write a simple bash script with a for loop

Often, you would like to run the same command with different parameters. As an exercise, write a simple bash script that will output numbers from 1 to 100. Use a for loop.

```
#!/bin/bash
for i in {1..100}
do
    echo $i
done
```

Save the above code to a file (e.g. `script.sh`), make the file executable (+x flag) and run it.



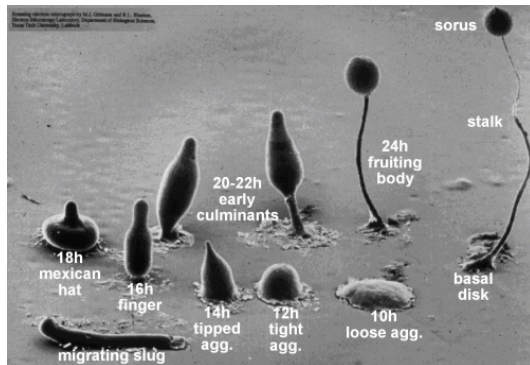
What is the output?



### Exercise 3: download the *Dictyostelium discoideum* (dd) genome in FASTA format

*Dictyostelium discoideum* ([www.dictybase.org](http://www.dictybase.org)) is an interesting social amoeba and a well studied model organism. The amoeba lives in the soil, and when nutrients run out, 100K amoebas aggregate into a

fruiting body. The stalk amoebas "sacrifice" themselves and the sorus is blown away by the wind to a new location with more nutrients (hopefully).



You can download the **dd genome FASTA** file directly from our server:

```
wget https://bioinfo.evolution.uzh.ch/share/bio609/dicty/dd.fasta
```

The FASTA format is widely used in sequence distribution, see the description at [http://en.wikipedia.org/wiki/FASTA\\_format](http://en.wikipedia.org/wiki/FASTA_format).

Use **grep** to find out how many chromosomes are present in the FASTA file. Then use **grep** (💡 -v) to only print out the genomic sequence (without chromosome identifiers). How large is the genome?

#### 📌 Exercise 4: searching for short sequences in the *Dictyostelium discoideum* genome

❓ Is the sequence "AAAAAGAGATACAT" present in the DD genome (dd.fasta)?

💡 You can simply use **grep** to find out.

❓ What is the downside of this approach (using search / grep to find short sequences) and why do we use short-read aligners like STAR, bowtie and others?

#### 📌 Exercise 5: handling RNA-seq data

Next-generation (short-read) sequencing data is usually stored in FASTQ files:  
[https://en.wikipedia.org/wiki/FASTQ\\_format](https://en.wikipedia.org/wiki/FASTQ_format)

FASTQ files are similar to FASTA files, but they also contain sequence quality.  
We will work with 10 FASTQ files (10 samples) containing sequences from *Dictyostelium discoideum* RNA (RNA-seq).

Write a short script to download \*.fastq.gz files from:

```
https://bioinfo.evolution.uzh.ch/share/bio609/dicty
```

Open the link in a browser and you should see 10 FASTQ files. Instead of clicking and downloading each file separately, write a script to download the files.

```
💡 for sample_id in {1..10}
```

In the for loop, you would need to adjust the name of the file and use command **wget** to download the files.



### Exercise 6: download and install a local version of STAR

Download the short-read aligner STAR and compile it. This is a good exercise to download and install software on your own on a Unix system.

```
git clone https://github.com/alexdobin/STAR
```

You see we use git to download the STAR source code from a GitHub repository. The "clone" just copies (clones) the repository from the web to your local folder.

Change to folder "source" and type "make". The software will compile. So you downloaded and compiled software from GitHub!



### Exercise 7: add the STAR binary to the path

If you type STAR in the command line, you will see that the program is not found. However if you type `./STAR`, the program will run, but only if you are in the source directory (where the file is located).

So that we can run STAR from any folder on the system, we will add the folder containing the binary file STAR to the profile PATH variable.

Edit the file `$HOME/.profile`, by typing:

```
vi $HOME/.profile
```

Edit the last line to include the path to the **STAR/source folder**. Add another ":" at the end of the line and add the full path to the STAR/source folder. If you now logout and login from your console and type STAR, the program should start. You need to login again since only at login (or when you start a new bash) the `.profile` file is read and executed.



### Exercise 8: map the RNA-seq data to the reference genome

We will now try to use STAR and map our 10 samples of RNA-seq data to the reference genome. First, you need to create an "index" for the `dd.fasta` reference genome. You can do this with:

```
mkdir istar # folder for genome index
STAR --runMode genomeGenerate --genomeDir istar --genomeFastaFiles dd.fasta
```

The command should take around 1-2 minutes to finish. The index is now stored in the folder **istar**.

Then you can write a script to map the RNA-seq data to the reference genome using the newly created index above.

An example command to map sample1 would be:

```
STAR --genomeDir istar --readFilesIn sample1.fastq.gz --readFilesCommand zcat
```

After finishing, this creates a SAM file (alignments) named **Aligned.out.sam**. For each of the 10 samples, rename this file into **samplen.sam** (where n=1,2,3..10) and convert the SAM file to a BAM file.

The "**pipeline**" for **sample1** could look something like this:

```
mv Aligned.out.sam sample1.sam
samtools view -bS sample1.sam > sample1.bam # convert sam to bam
samtools sort sample1.bam -o sample1.bam # sort bam file
samtools index sample1.bam # index bam file
rm sample1.sam # remove sample1.sam, since we don't need it anymore
```

Write a short script to repeat the above steps for all the 10 samples (sample1, sample2, ... sample10). Of course here comes the power of bash, simply use a for loop.



### **Exercise 9: download genome annotation in GFF format and count reads aligned to genes**

Download the GTF file (genome annotation) for *Dictyosrteium discoideum* from:

```
wget https://bioinfo.evolution.uzh.ch/share/bio609/dicty/dd.gtf
htseq-count -f bam sample1.bam dd.gtf > sample1.tab
```

Repeat this for all the samples, so in the end you should get 10 tab files with gene counts.




### **\* Exercise 10: combine gene expression tables into one single table**

This one is tricky, but you can use awk:

```
awk 'NF > 1{ a[$1] = a[$1]"\t"$2} END {for( i in a ) print i a[i]}' *.tab >
samples.tab
```

Stores the big table into the file **samples.tab**.

\*  **Exercise 11: try to download and compile bowtie2, make an index of the genome and map the reads to the reference genome, count the reads aligning to genes and create the samples.tab table. Compare the STAR to the bowtie2 mappings.**

## System information, processes and other useful commands

<b>uname -a</b>	display system information
<b>man</b> <i>command</i>	display manual page of command
<b>df -h</b>	list mounted disks with available space
<b>du -h</b> <i>path</i>	show space usage
<b>top</b>	display running processes
<b>kill -9</b> <i>pid</i>	kill process

## File and folder manipulation, compression

<b>pwd</b>	display current folder
<b>ls -l</b> <i>path</i>	list files and folders
<b>cd</b> <i>path</i>	change folder to path
<b>cd</b> ~	change folder to home folder
<b>mkdir</b> <i>name</i>	make folder
<b>rmdir</b> <i>name</i>	remove folder
<b>cp</b> <i>source dest</i>	copy file/folder and all its contents
<b>less</b> <i>filename</i>	display file content
<b>wc</b> <i>filename</i>	count number of lines in file
<b>head</b> <i>filename</i>	shows first few lines of file
<b>tail</b> <i>filename</i>	shows last few lines of file
<b>gzip</b> <i>filename</i>	compress file with gzip (adds .gz extension)
<b>gunzip</b> <i>filename</i>	uncompress and remove .gz extension
<b>tar xzf</b> <i>filename.tar.gz</i>	uncompress files from tar.gz archive
<b>tar zcvf</b> <i>archive.tar.gz folder_to_compress</i>	creates archive.tar.gz
<b>unzip</b> <i>filename.zip</i>	unzip archive

## Network and file transfer

<b>wget</b> URL	download file (html page) and save to current folder
<b>ssh</b> <i>username@host</i>	remote login to host with username
<b>sftp</b> <i>username@host</i>	remote login to host with username and transfer files

## “vi” editor

<b>\$ vi</b> <i>filename</i>	start editing file with vi
<b>i</b>	switch to “insert” mode
<b>ESC</b>	switch to “command” mode
<b>:w</b>	save
<b>:q</b>	quit
<b>:x</b>	save and quit
<b>/&lt;pattern&gt;</b>	search for pattern, <n> gives you the next match
<b>:q!</b>	quit without saving changes