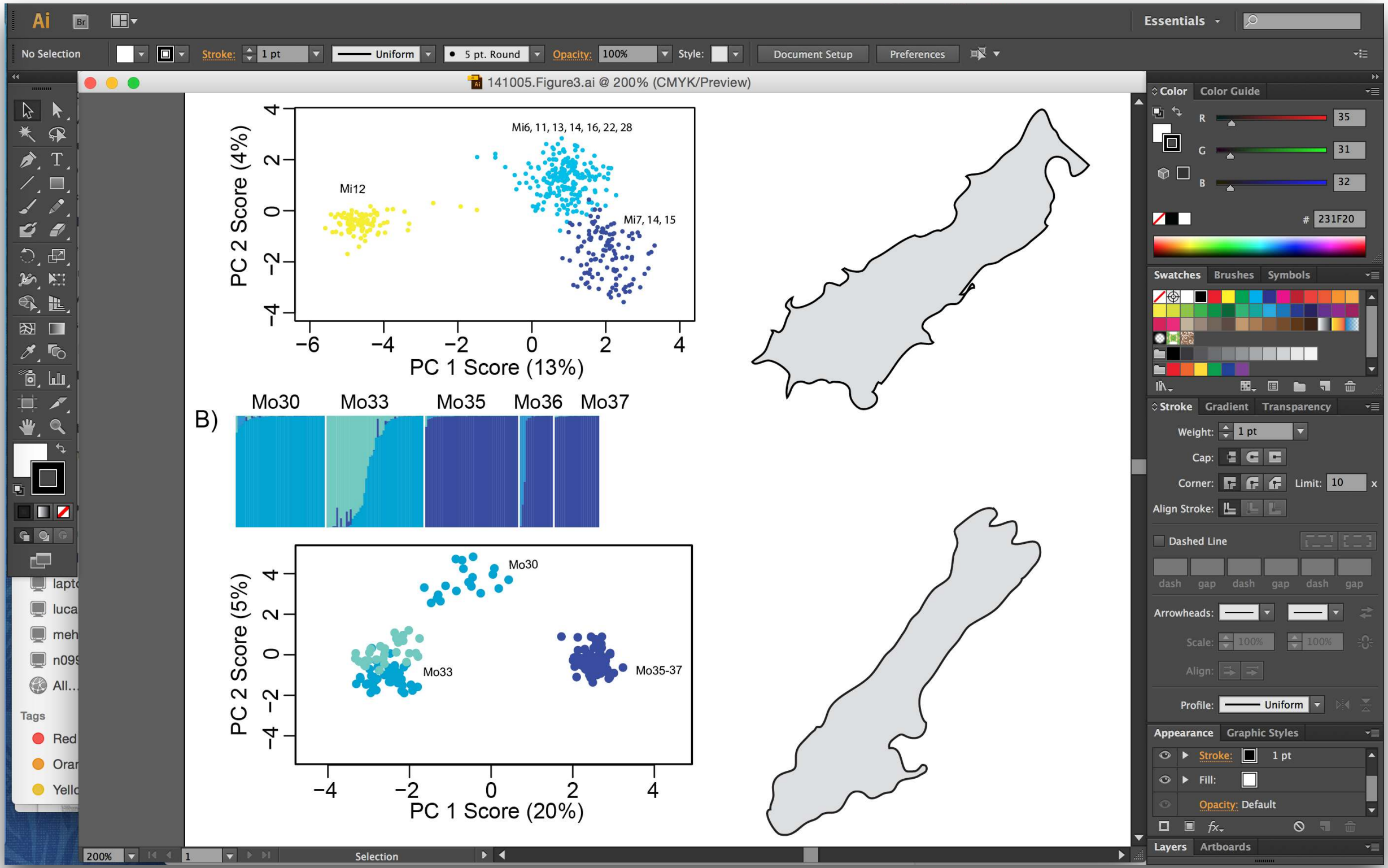


digital™

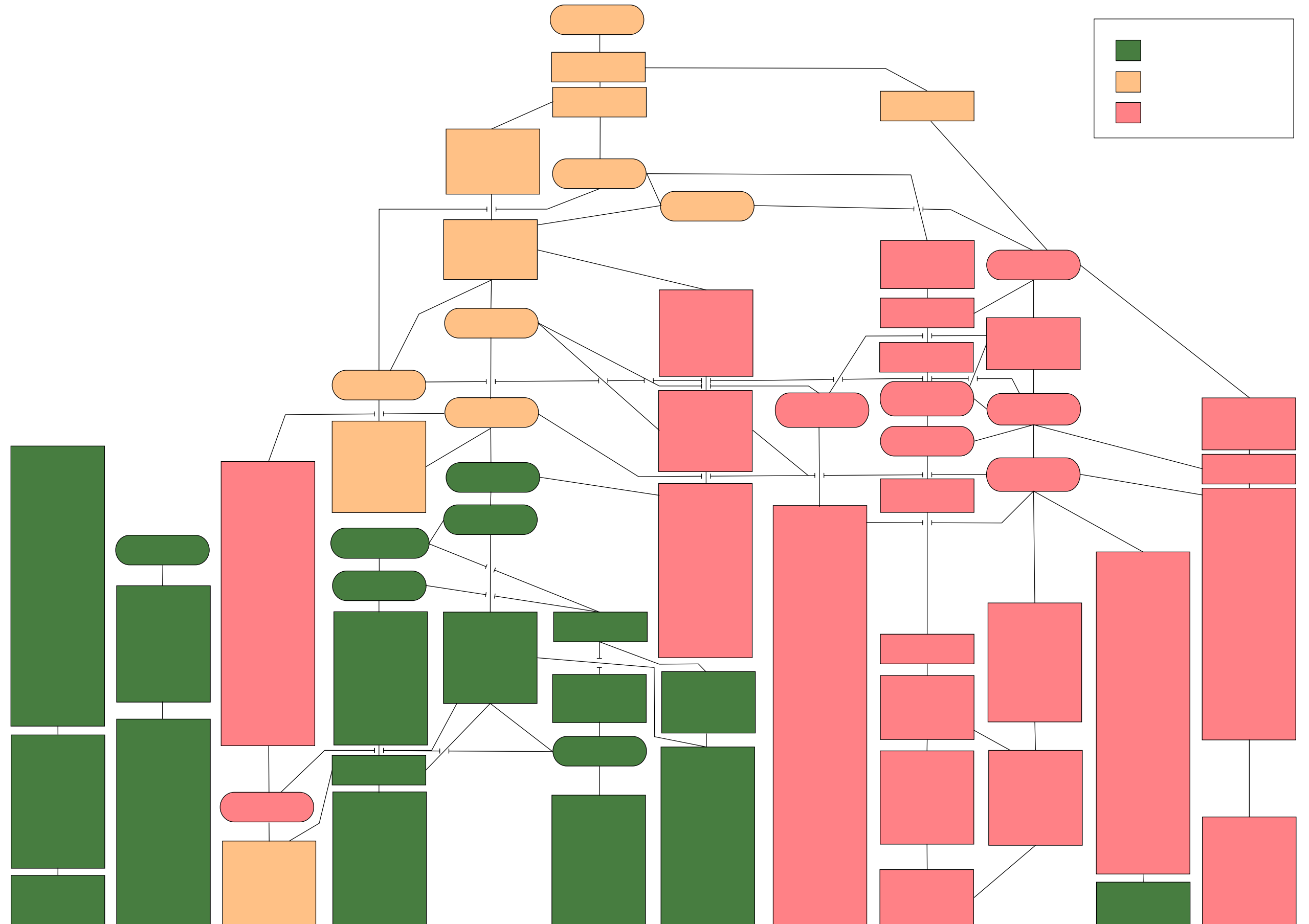
LIVE FREE OR DIE

UNIX

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Unix History



What computers can run Unix?

What computers can run Unix?



Apple OS X Macs

What computers can run Unix?



Apple OS X Macs



Wireless internet routers

What computers can run Unix?



Apple OS X Macs



Google's Android phones



Wireless internet routers

What computers can run Unix?



Apple OS X Macs



Wireless internet routers



Google's Android phones

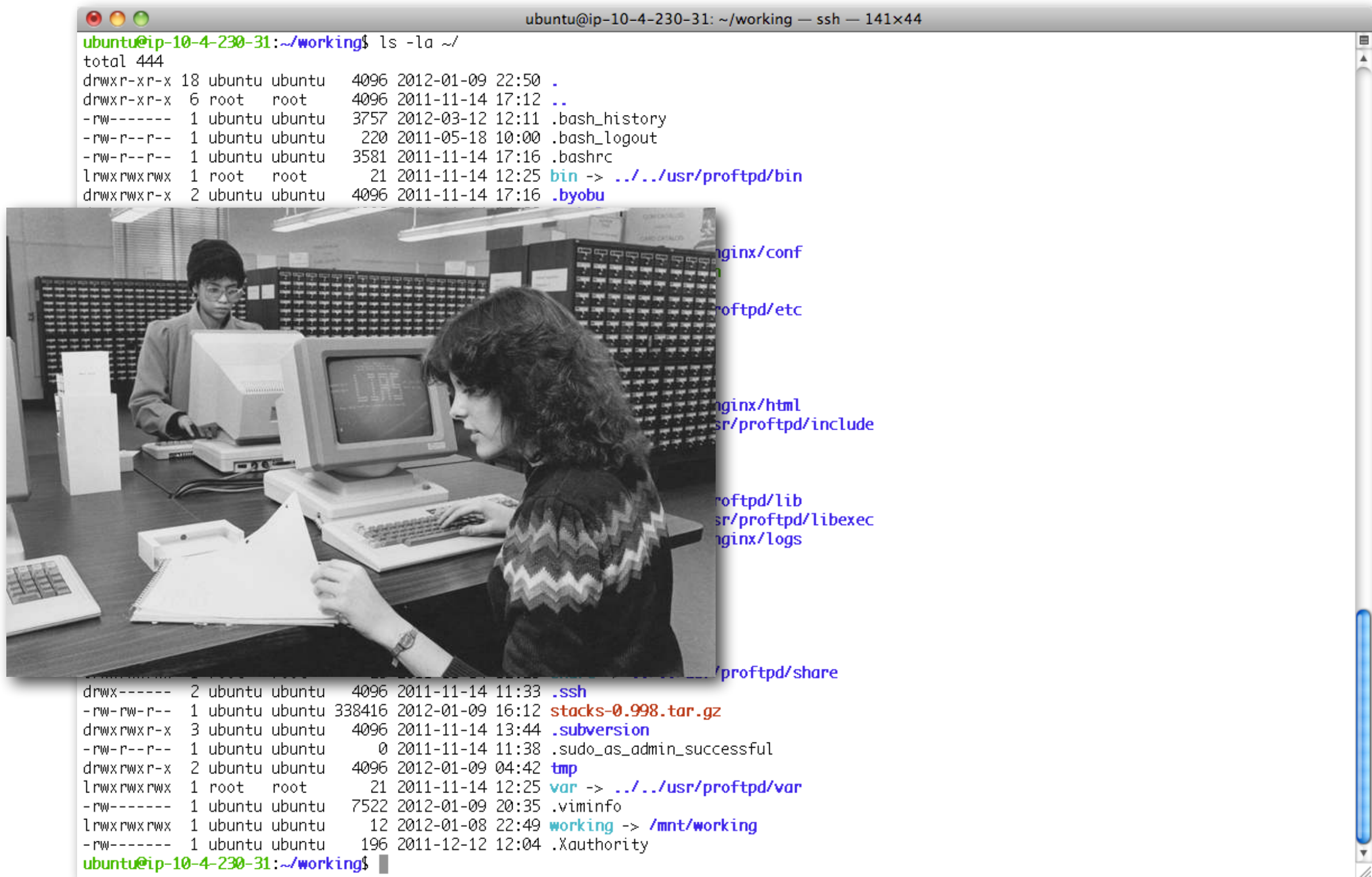


Airplane
entertainment
systems

The Terminal Window

```
ubuntu@ip-10-4-230-31: ~/working — ssh — 141x44
ubuntu@ip-10-4-230-31:~/working$ ls -la ~/
total 444
drwxr-xr-x 18 ubuntu ubuntu 4096 2012-01-09 22:50 .
drwxr-xr-x  6 root   root   4096 2011-11-14 17:12 ..
-rw-----  1 ubuntu ubuntu 3757 2012-03-12 12:11 .bash_history
-rw-r--r--  1 ubuntu ubuntu  220 2011-05-18 10:00 .bash_logout
-rw-r--r--  1 ubuntu ubuntu 3581 2011-11-14 17:16 .bashrc
lrwxrwxrwx  1 root   root    21 2011-11-14 12:25 bin -> ../../usr/proftpd/bin
drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 17:16 .byobu
drwxrwxr-x  4 ubuntu ubuntu 4096 2011-11-14 14:33 .cabal
drwx-----  3 ubuntu ubuntu 4096 2011-11-14 11:37 .cache
lrwxrwxrwx  1 root   root    20 2011-11-14 12:23 conf -> ../../usr/nginx/conf
-rwxrwxrwx  1 ubuntu ubuntu  992 2011-11-14 17:12 configure_freemx.sh
drwx-----  3 ubuntu ubuntu 4096 2012-01-08 22:52 .emacs.d
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drwxr-xr-x  2 ubuntu ubuntu 4096 2011-11-14 12:51 .fontconfig
drwx-----  2 ubuntu ubuntu 4096 2011-11-14 14:18 .gconf
drwxr-xr-x  3 root   root   4096 2011-11-14 16:58 .gem
drwx-----  2 ubuntu ubuntu 4096 2011-11-14 14:51 .gnupg
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drwxrwxr-x  3 ubuntu ubuntu 4096 2011-11-14 12:27 .lein
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drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 12:51 .m2
drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 14:18 .matplotlib
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-rw-r--r--  1 ubuntu ubuntu  675 2011-11-14 17:16 .profile
drwxr-xr-x  2 root   root   4096 2011-11-14 12:25 sbin
-rw-rw-r--  1 ubuntu ubuntu  0 2011-11-14 11:37 .screenrc
lrwxrwxrwx  1 root   root    23 2011-11-14 12:25 share -> ../../usr/proftpd/share
drwx-----  2 ubuntu ubuntu 4096 2011-11-14 11:33 .ssh
-rw-rw-r--  1 ubuntu ubuntu 338416 2012-01-09 16:12 stacks-0.998.tar.gz
drwxrwxr-x  3 ubuntu ubuntu 4096 2011-11-14 13:44 .subversion
-rw-r--r--  1 ubuntu ubuntu  0 2011-11-14 11:38 .sudo_as_admin_successful
drwxrwxr-x  2 ubuntu ubuntu 4096 2012-01-09 04:42 tmp
lrwxrwxrwx  1 root   root    21 2011-11-14 12:25 var -> ../../usr/proftpd/var
-rw-----  1 ubuntu ubuntu 7522 2012-01-09 20:35 .viminfo
lrwxrwxrwx  1 ubuntu ubuntu  12 2012-01-08 22:49 working -> /mnt/working
-rw-----  1 ubuntu ubuntu  196 2011-12-12 12:04 .Xauthority
ubuntu@ip-10-4-230-31:~/working$
```

The Terminal Window



The terminal window displays the output of the command `ls -la ~/`. The output shows a list of files and directories in the user's home directory. The files include `.bash_history`, `.bash_logout`, `.bashrc`, `.bin`, `.byobu`, `.nginx/conf`, `.proftpd/etc`, `.nginx/html`, `.sr/proftpd/include`, `.proftpd/lib`, `.sr/proftpd/libexec`, `.nginx/logs`, `.proftpd/share`, `.ssh`, `stacks-0.998.tar.gz`, `.subversion`, `.sudo_as_admin_successful`, `.tmp`, `.var`, `.viminfo`, `.working`, and `.Xauthority`.

The photograph shows two people working at computers in a room with many computer monitors. The person in the foreground is a woman with dark hair, wearing a patterned sweater, looking at a computer screen. The person in the background is a man with glasses, also looking at a computer screen. The room has many computer monitors and a desk with papers and a keyboard.

```
ubuntu@ip-10-4-230-31: ~/working — ssh — 141x44
ubuntu@ip-10-4-230-31:~/working$ ls -la ~/
total 444
drwxr-xr-x 18 ubuntu ubuntu 4096 2012-01-09 22:50 .
drwxr-xr-x  6 root    root   4096 2011-11-14 17:12 ..
-rw-----  1 ubuntu ubuntu 3757 2012-03-12 12:11 .bash_history
-rw-r--r--  1 ubuntu ubuntu  220 2011-05-18 10:00 .bash_logout
-rw-r--r--  1 ubuntu ubuntu 3581 2011-11-14 17:16 .bashrc
lrwxrwxrwx  1 root    root    21 2011-11-14 12:25 .bin -> ../../usr/proftpd/bin
drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 17:16 .byobu
      .nginx/conf
      .proftpd/etc
      .nginx/html
      .sr/proftpd/include
      .proftpd/lib
      .sr/proftpd/libexec
      .nginx/logs
      .proftpd/share
drwx-----  2 ubuntu ubuntu 4096 2011-11-14 11:33 .ssh
-rw-rw-r--  1 ubuntu ubuntu 338416 2012-01-09 16:12 stacks-0.998.tar.gz
drwxrwxr-x  3 ubuntu ubuntu 4096 2011-11-14 13:44 .subversion
-rw-r--r--  1 ubuntu ubuntu  0 2011-11-14 11:38 .sudo_as_admin_successful
drwxrwxr-x  2 ubuntu ubuntu 4096 2012-01-09 04:42 .tmp
lrwxrwxrwx  1 root    root    21 2011-11-14 12:25 .var -> ../../usr/proftpd/var
-rw-----  1 ubuntu ubuntu 7522 2012-01-09 20:35 .viminfo
lrwxrwxrwx  1 ubuntu ubuntu  12 2012-01-08 22:49 .working -> /mnt/working
-rw-----  1 ubuntu ubuntu  196 2011-12-12 12:04 .Xauthority
ubuntu@ip-10-4-230-31:~/working$
```


The Terminal Window

ubuntu@ip-10-4-230-31: ~/working — ssh — 141x44

```
ubuntu@ip-10-4-230-31:~/working$ ls -la ~/
total 444
drwxr-xr-x 18 ubuntu ubuntu 4096 2012-01-09 22:50 .
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-rw-----  1 ubuntu ubuntu 3757 2012-03-12 12:11 .bash_history
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lrwxrwxrwx  1 root   root    21 2011-11-14 12:25 bin -> ../../usr/proftpd/bin
drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 17:16 .byobu
```



nginx/conf

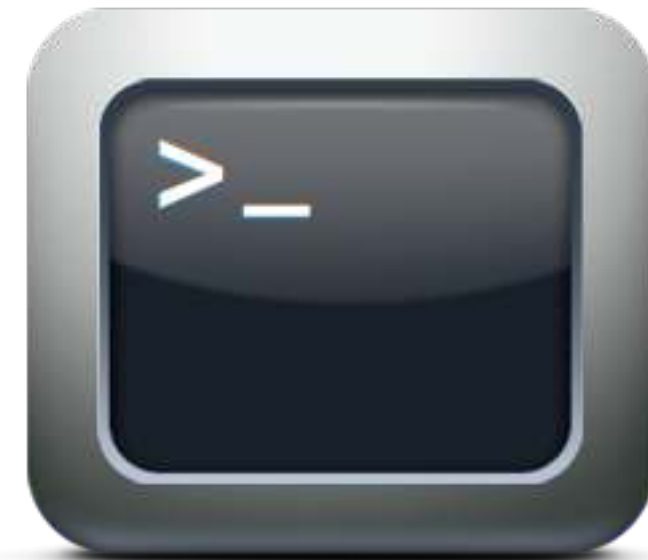
proftpd/etc

nginx/html
usr/proftpd/include

proftpd/lib
usr/proftpd/libexec
nginx/logs

proftpd/share

```
drwx----- 2 ubuntu ubuntu 4096 2011-11-14 11:33 .ssh
-rw-rw-r--  1 ubuntu ubuntu 338416 2012-01-09 16:12 stacks-0.998.tar.gz
drwxrwxr-x  3 ubuntu ubuntu 4096 2011-11-14 13:44 .subversion
-rw-r--r--  1 ubuntu ubuntu  0 2011-11-14 11:38 .sudo_as_admin_successful
drwxrwxr-x  2 ubuntu ubuntu 4096 2012-01-09 04:42 tmp
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-rw-----  1 ubuntu ubuntu  196 2011-12-12 12:04 .Xauthority
ubuntu@ip-10-4-230-31:~/working$
```



The Terminal Window

ubuntu@ip-10-4-230-31: ~/working — ssh — 141x44

```
ubuntu@ip-10-4-230-31:~/working$ ls -la ~/
total 444
drwxr-xr-x 18 ubuntu ubuntu 4096 2012-01-09 22:50 .
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drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 17:16 .byobu
```

nginx/conf
proftpd/etc
nginx/html
usr/proftpd/include
proftpd/lib
usr/proftpd/libexec
nginx/logs
proftpd/share

drwx----- 2 ubuntu ubuntu 4096 2011-11-14 11:33 .ssh
-rw-rw-r-- 1 ubuntu ubuntu 338416 2012-01-09 16:12 stacks-0.998.tar.gz
drwxrwxr-x 3 ubuntu ubuntu 4096 2011-11-14 13:44 .subversion
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drwxrwxr-x 2 ubuntu ubuntu 4096 2012-01-09 04:42 tmp
lrwxrwxrwx 1 root root 21 2011-11-14 12:25 var -> ../../usr/proftpd/var
-rw----- 1 ubuntu ubuntu 7522 2012-01-09 20:35 .viminfo
lrwxrwxrwx 1 ubuntu ubuntu 12 2012-01-08 22:49 working -> /mnt/working
-rw----- 1 ubuntu ubuntu 196 2011-12-12 12:04 .Xauthority

ubuntu@ip-10-4-230-31:~/working\$

the shell, the prompt, the command line

The Terminal Window

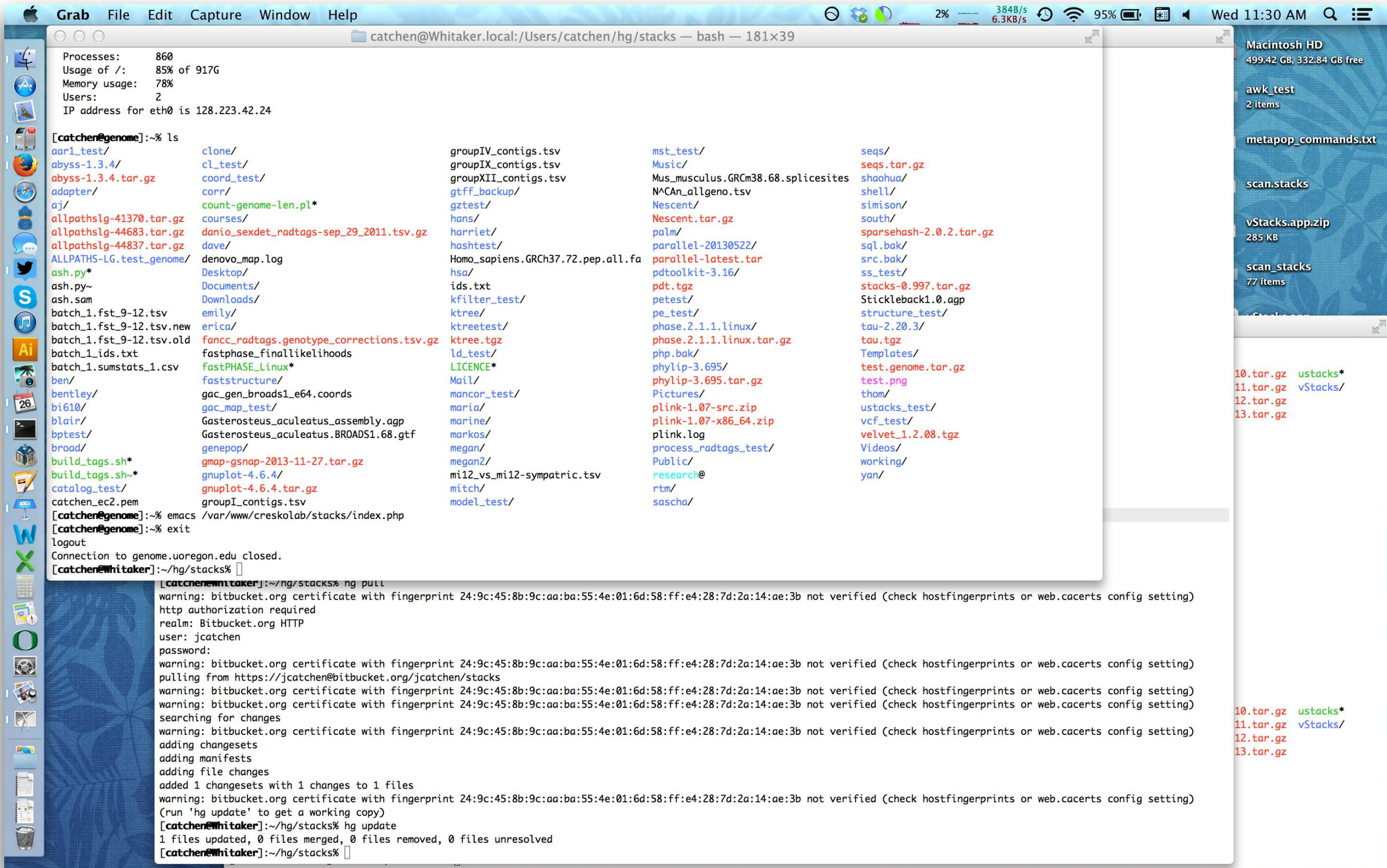
```
ubuntu@ip-10-4-230-31: ~/working — ssh — 141x44
ubuntu@ip-10-4-230-31:~/working$ ls -la ~/
total 444
drwxr-xr-x 18 ubuntu ubuntu 4096 2012-01-09 22:50 .
drwxr-xr-x  6 root   root   4096 2011-11-14 17:12 ..
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drwx----- 3 ubuntu ubuntu 4096 2011-11-14 11:37 .cache
lrwxrwxrwx  1 root   root    20 2011-11-14 12:23 conf -> ../../usr/nginx/conf
-rwxrwxrwx  1 ubuntu ubuntu  992 2011-11-14 17:12 configure_freemx.sh
drwx----- 3 ubuntu ubuntu 4096 2012-01-08 22:52 .emacs.d
lrwxrwxrwx  1 root   root    21 2011-11-14 12:25 etc -> ../../usr/proftpd/etc
drwxr-xr-x  2 ubuntu ubuntu 4096 2011-11-14 12:51 .fontconfig
drwx----- 2 ubuntu ubuntu 4096 2011-11-14 14:18 .gconf
drwxr-xr-x  3 root   root   4096 2011-11-14 16:58 .gem
drwx----- 2 ubuntu ubuntu 4096 2011-11-14 14:51 .gnupg
lrwxrwxrwx  1 root   root    20 2011-11-14 12:23 html -> ../../usr/nginx/html
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drwxrwxr-x  4 ubuntu ubuntu 4096 2011-11-28 17:49 install
drwxrwxr-x  3 ubuntu ubuntu 4096 2011-11-14 12:27 .lein
-rw-r----- 1 ubuntu ubuntu  65 2011-11-14 13:07 .lessht
lrwxrwxrwx  1 root   root    21 2011-11-14 12:25 lib -> ../../usr/proftpd/lib
lrwxrwxrwx  1 root   root    25 2011-11-14 12:25 libexec -> ../../usr/proftpd/libexec
lrwxrwxrwx  1 root   root    20 2011-11-14 12:23 logs -> ../../usr/nginx/logs
drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 12:51 .m2
drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 14:18 .matplotlib
-rw-r----- 1 ubuntu ubuntu 2964 2012-01-09 22:50 .mysql_history
-rw-r--r--  1 ubuntu ubuntu  675 2011-11-14 17:16 .profile
drwxr-xr-x  2 root   root   4096 2011-11-14 12:25 sbin
-rw-rw-r--  1 ubuntu ubuntu  0 2011-11-14 11:37 .screenrc
lrwxrwxrwx  1 root   root    23 2011-11-14 12:25 share -> ../../usr/proftpd/share
drwx----- 2 ubuntu ubuntu 4096 2011-11-14 11:33 .ssh
-rw-rw-r--  1 ubuntu ubuntu 338416 2012-01-09 16:12 stacks-0.998.tar.gz
drwxrwxr-x  3 ubuntu ubuntu 4096 2011-11-14 13:44 .subversion
-rw-r--r--  1 ubuntu ubuntu  0 2011-11-14 11:38 .sudo_as_admin_successful
drwxrwxr-x  2 ubuntu ubuntu 4096 2012-01-09 04:42 tmp
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ubuntu@ip-10-4-230-31:~/working$
```

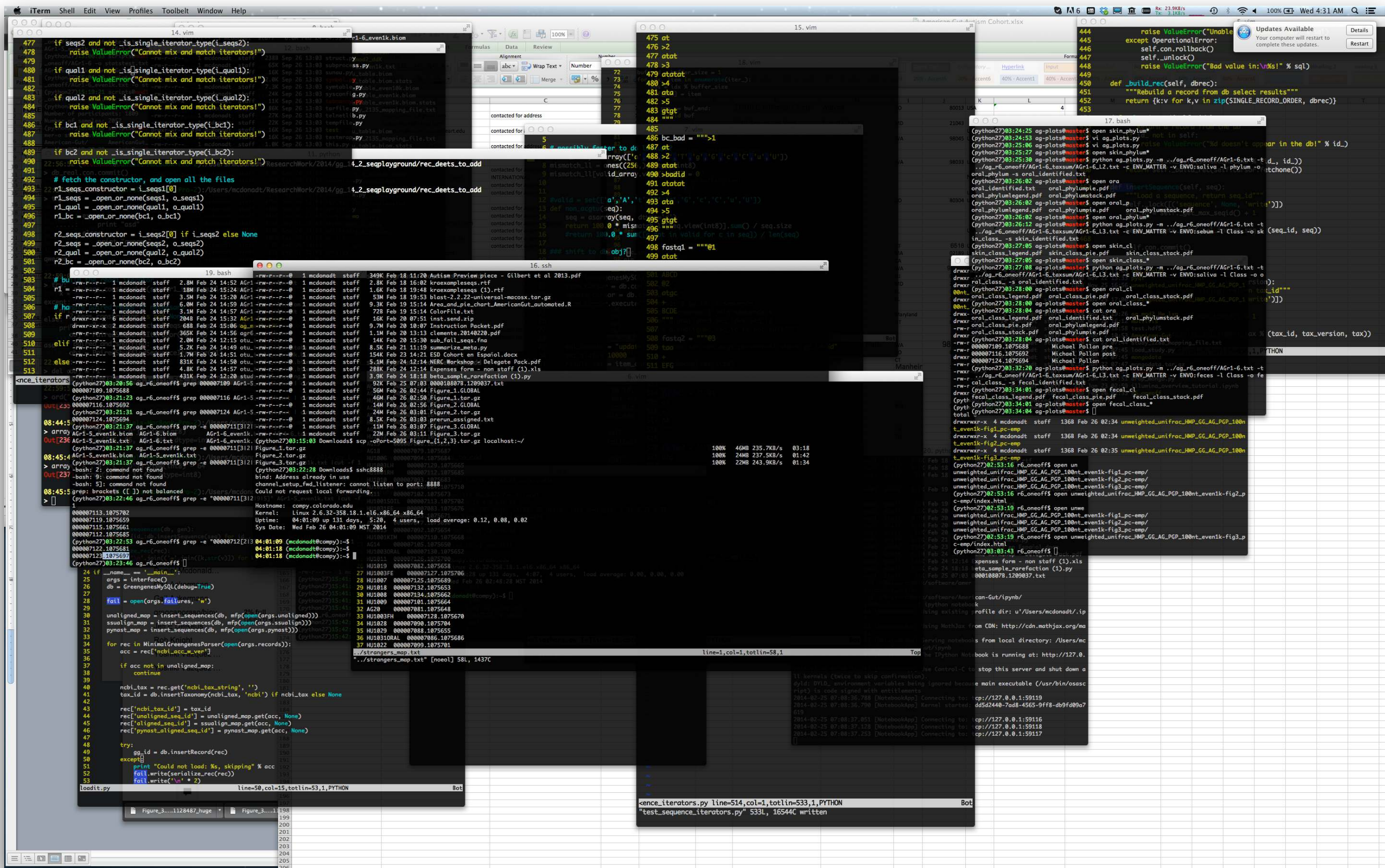
The Terminal Window

```
ubuntu@ip-10-4-230-31: ~/working — ssh — 141x44
ubuntu@ip-10-4-230-31:~/working$ ls -la ~/
total 444
drwxr-xr-x 18 ubuntu ubuntu 4096 2012-01-09 22:50 .
drwxr-xr-x  6 root   root   4096 2011-11-14 17:12 ..
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drwxrwxr-x  2 ubuntu ubuntu 4096 2011-11-14 17:16 .byobu
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lrwxrwxrwx  1 root   root    20 2011-11-14 12:23 conf -> ../../usr/nginx/conf
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-rw-rw-r--  1 ubuntu ubuntu 338416 2012-01-09 16:12 stacks-0.998.tar.gz
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-rw-r----- 1 ubuntu ubuntu 7522 2012-01-09 20:35 .viminfo
lrwxrwxrwx  1 ubuntu ubuntu  12 2012-01-08 22:49 working -> /mnt/working
-rw-r----- 1 ubuntu ubuntu  196 2011-12-12 12:04 .xauthority
ubuntu@ip-10-4-230-31:~/working$
```

Make it comfortable to work in:

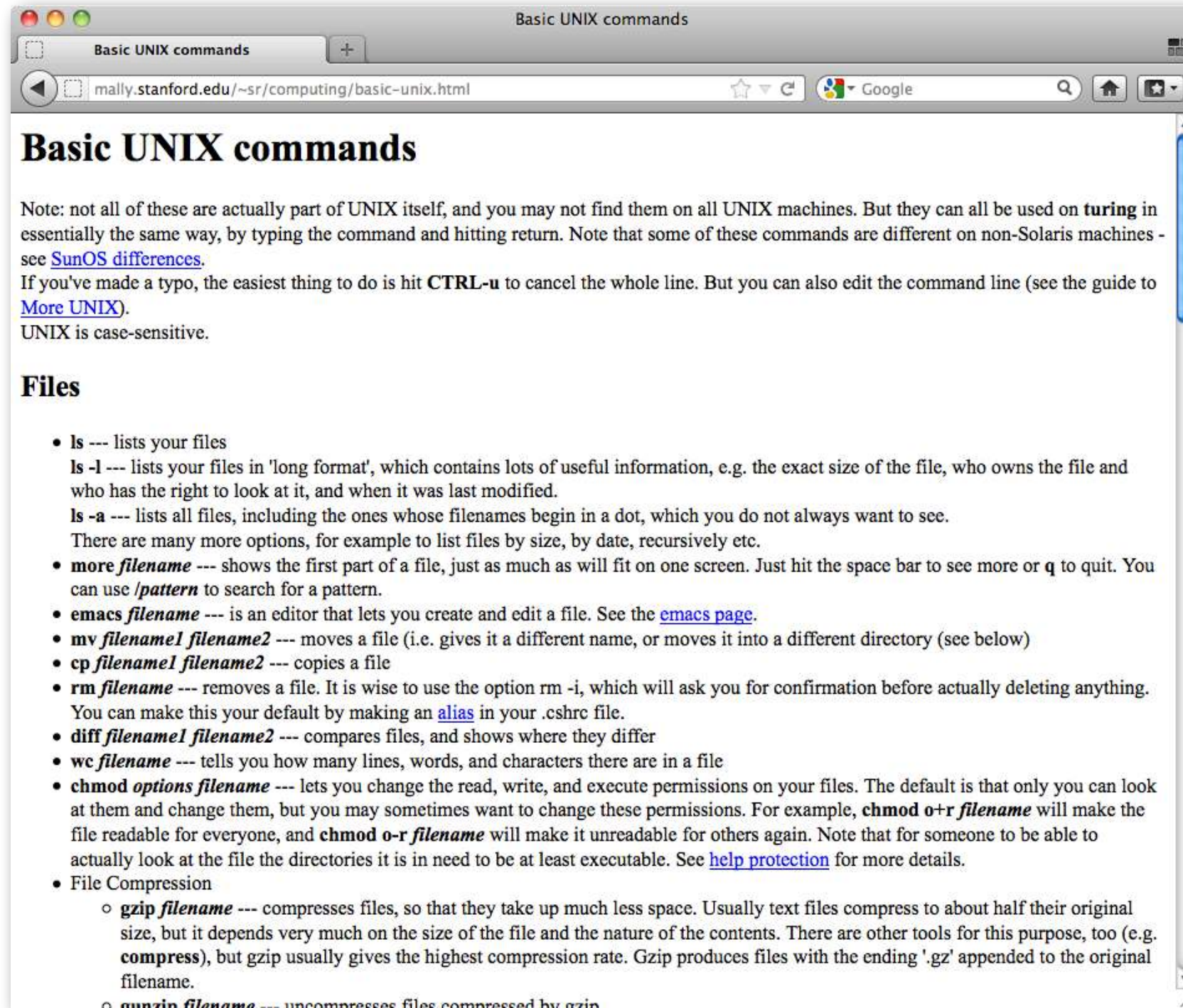
- Resize the window
- Change your font size
- Open multiple terminal windows





Obtain a cheat sheet

google “unix commands”



The screenshot shows a web browser window with the title 'Basic UNIX commands'. The address bar displays the URL 'mally.stanford.edu/~sr/computing/basic-unix.html'. The page content is titled 'Basic UNIX commands' and includes a note about command availability, instructions on using CTRL-u to cancel a line, and a warning that UNIX is case-sensitive. A section titled 'Files' lists various UNIX commands with their functions and options, such as ls, more, emacs, mv, cp, rm, diff, wc, chmod, and file compression tools like gzip and gunzip.

Basic UNIX commands

Note: not all of these are actually part of UNIX itself, and you may not find them on all UNIX machines. But they can all be used on **turing** in essentially the same way, by typing the command and hitting return. Note that some of these commands are different on non-Solaris machines - see [SunOS differences](#).
If you've made a typo, the easiest thing to do is hit **CTRL-u** to cancel the whole line. But you can also edit the command line (see the guide to [More UNIX](#)).
UNIX is case-sensitive.

Files

- **ls** --- lists your files
 - ls -l** --- lists your files in 'long format', which contains lots of useful information, e.g. the exact size of the file, who owns the file and who has the right to look at it, and when it was last modified.
 - ls -a** --- lists all files, including the ones whose filenames begin in a dot, which you do not always want to see.
- There are many more options, for example to list files by size, by date, recursively etc.
- **more filename** --- shows the first part of a file, just as much as will fit on one screen. Just hit the space bar to see more or **q** to quit. You can use */pattern* to search for a pattern.
- **emacs filename** --- is an editor that lets you create and edit a file. See the [emacs page](#).
- **mv filename1 filename2** --- moves a file (i.e. gives it a different name, or moves it into a different directory (see below))
- **cp filename1 filename2** --- copies a file
- **rm filename** --- removes a file. It is wise to use the option **rm -i**, which will ask you for confirmation before actually deleting anything. You can make this your default by making an [alias](#) in your **.cshrc** file.
- **diff filename1 filename2** --- compares files, and shows where they differ
- **wc filename** --- tells you how many lines, words, and characters there are in a file
- **chmod options filename** --- lets you change the read, write, and execute permissions on your files. The default is that only you can look at them and change them, but you may sometimes want to change these permissions. For example, **chmod o+r filename** will make the file readable for everyone, and **chmod o-r filename** will make it unreadable for others again. Note that for someone to be able to actually look at the file the directories it is in need to be at least executable. See [help protection](#) for more details.
- File Compression
 - **gzip filename** --- compresses files, so that they take up much less space. Usually text files compress to about half their original size, but it depends very much on the size of the file and the nature of the contents. There are other tools for this purpose, too (e.g. **compress**), but gzip usually gives the highest compression rate. Gzip produces files with the ending '.gz' appended to the original filename.
 - **gunzip filename** --- uncompresses files compressed by gzip

In UNIX everything is a file organized in a hierarchy

Paths

`/home/catchen/working`

Create a series of directories

```
ubuntu@ip-10-4-193-188:~$ mkdir shell
ubuntu@ip-10-4-193-188:~$ cd shell
ubuntu@ip-10-4-193-188:~/shell$ mkdir research
ubuntu@ip-10-4-193-188:~/shell$ ls
research
ubuntu@ip-10-4-193-188:~/shell$ cd research/
ubuntu@ip-10-4-193-188:~/shell/research$ mkdir seq
ubuntu@ip-10-4-193-188:~/shell/research$ ls
seq
ubuntu@ip-10-4-193-188:~/shell/research$ cd seq/
ubuntu@ip-10-4-193-188:~/shell/research/seq$ mkdir radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq$ cd radtags/
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls -la
total 8
drwxrwxr-x 2 ubuntu ubuntu 4096 2012-03-06 23:08 .
drwxrwxr-x 3 ubuntu ubuntu 4096 2012-03-06 23:08 ..
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ pwd
/home/ubuntu/shell/research/seq/radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$
```

Create a series of directories

```
ubuntu@ip-10-4-193-188:~$ mkdir shell
ubuntu@ip-10-4-193-188:~$ cd shell
ubuntu@ip-10-4-193-188:~/shell$ mkdir research
ubuntu@ip-10-4-193-188:~/shell$ ls
research
ubuntu@ip-10-4-193-188:~/shell$ cd research/
ubuntu@ip-10-4-193-188:~/shell/research$ mkdir seq
ubuntu@ip-10-4-193-188:~/shell/research$ ls
seq
ubuntu@ip-10-4-193-188:~/shell/research$ cd seq/
ubuntu@ip-10-4-193-188:~/shell/research/seq$ mkdir radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq$ cd radtags/
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls -la
total 8
drwxrwxr-x 2 ubuntu ubuntu 4096 2012-03-06 23:08 .
drwxrwxr-x 3 ubuntu ubuntu 4096 2012-03-06 23:08 ..
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ pwd
/home/ubuntu/shell/research/seq/radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$
```

% mkdir shell

% cd shell

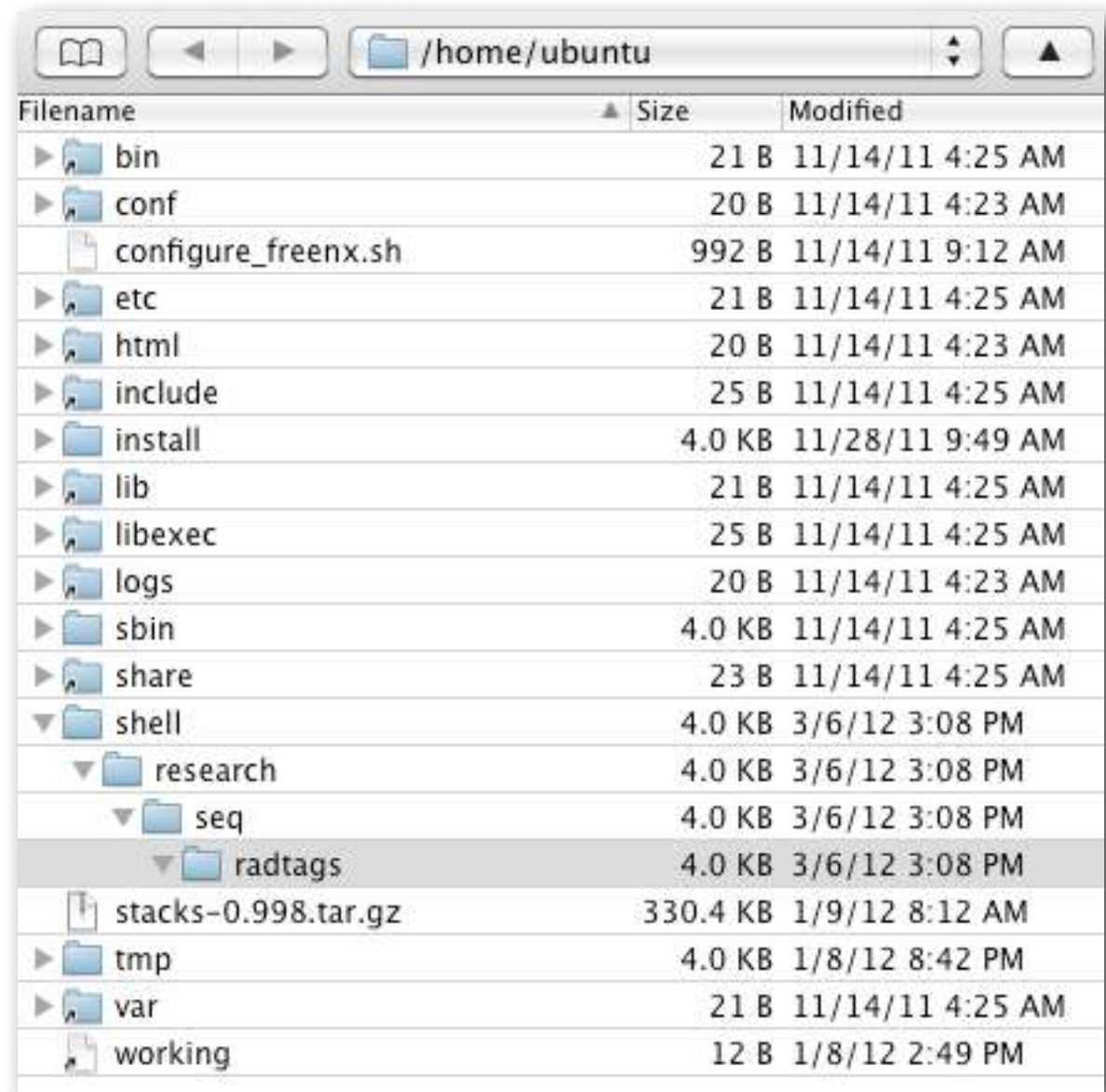
% ls

Paths, cont

This shell view of the nested directories shell, research, seq, and radtags.....

```
ubuntu@ip-10-4-193-188:~$ mkdir shell
ubuntu@ip-10-4-193-188:~$ cd shell
ubuntu@ip-10-4-193-188:~/shell$ mkdir research
ubuntu@ip-10-4-193-188:~/shell$ ls
research
ubuntu@ip-10-4-193-188:~/shell$ cd research/
ubuntu@ip-10-4-193-188:~/shell/research$ mkdir seq
ubuntu@ip-10-4-193-188:~/shell/research$ ls
seq
ubuntu@ip-10-4-193-188:~/shell/research$ cd seq/
ubuntu@ip-10-4-193-188:~/shell/research/seq$ mkdir radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq$ cd radtags/
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls
total 8
drwxrwxr-x 2 ubuntu ubuntu 4096 2012-03-06 23:08 .
drwxrwxr-x 3 ubuntu ubuntu 4096 2012-03-06 23:08 ..
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ pwd
/home/ubuntu/shell/research/seq/radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$
```

.... is equivalent to this GUI view of the same directories

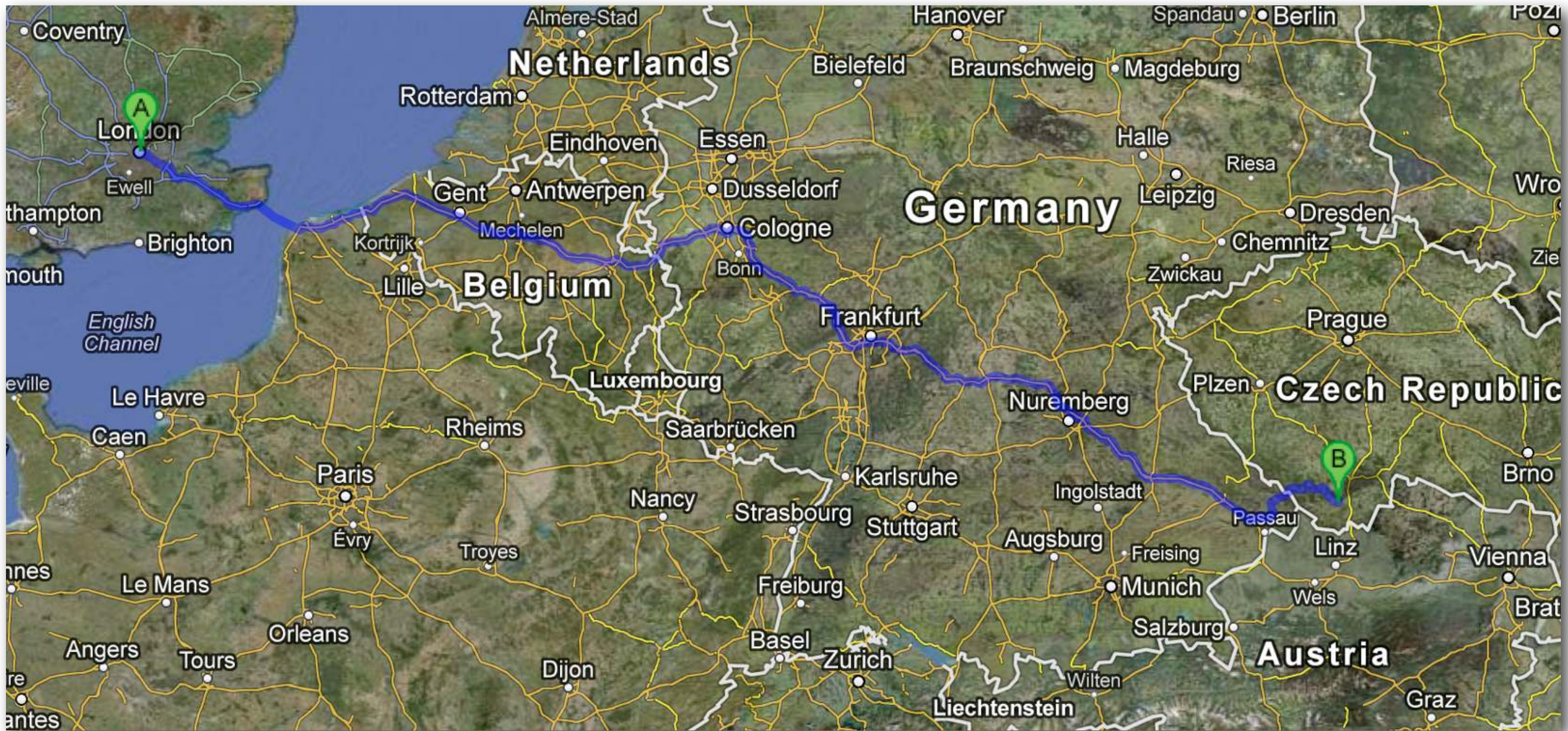


Filename	Size	Modified
bin	21 B	11/14/11 4:25 AM
conf	20 B	11/14/11 4:23 AM
configure_freenx.sh	992 B	11/14/11 9:12 AM
etc	21 B	11/14/11 4:25 AM
html	20 B	11/14/11 4:23 AM
include	25 B	11/14/11 4:25 AM
install	4.0 KB	11/28/11 9:49 AM
lib	21 B	11/14/11 4:25 AM
libexec	25 B	11/14/11 4:25 AM
logs	20 B	11/14/11 4:23 AM
sbin	4.0 KB	11/14/11 4:25 AM
share	23 B	11/14/11 4:25 AM
shell	4.0 KB	3/6/12 3:08 PM
research	4.0 KB	3/6/12 3:08 PM
seq	4.0 KB	3/6/12 3:08 PM
radtags	4.0 KB	3/6/12 3:08 PM
stacks-0.998.tar.gz	330.4 KB	1/9/12 8:12 AM
tmp	4.0 KB	1/8/12 8:42 PM
var	21 B	11/14/11 4:25 AM
working	12 B	1/8/12 2:49 PM

And the radtags directory is uniquely identified by its path:
/home/ubuntu/shell/research/seq/radtags

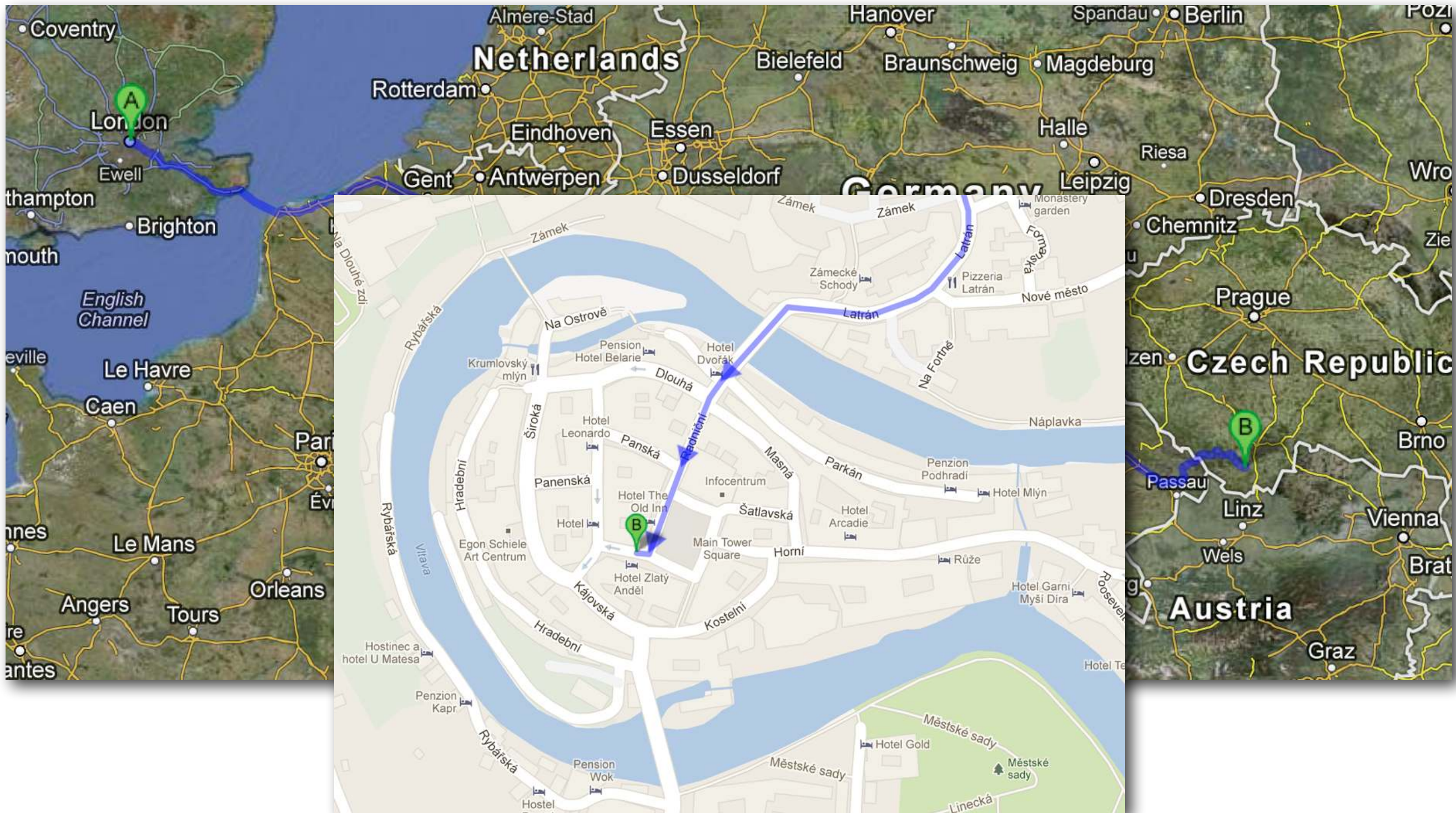
Absolute and relative paths

How do I get to the Hotel Zlaty Andel?



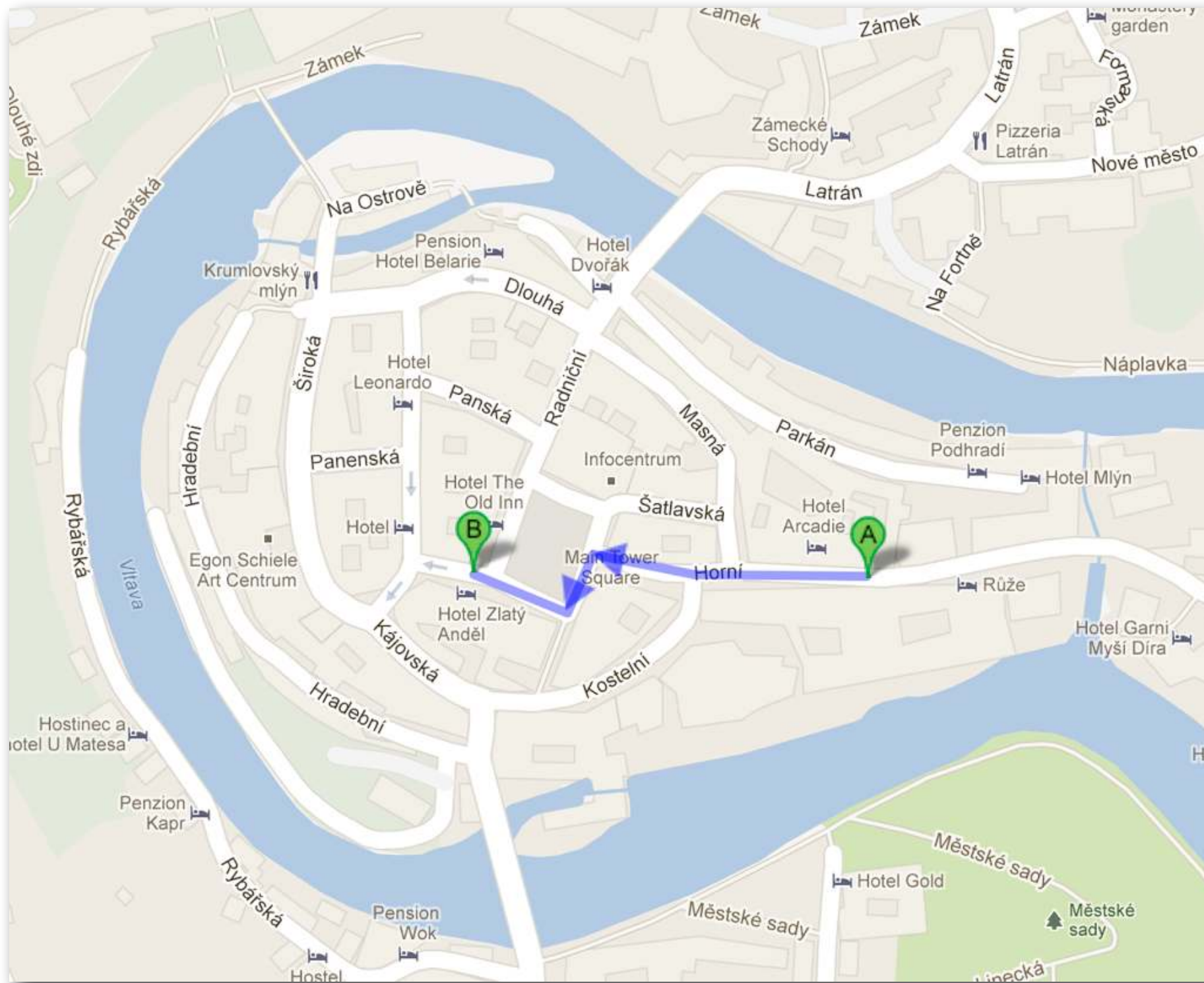
Absolute and relative paths

How do I get to the Hotel Zlatý Anděl?

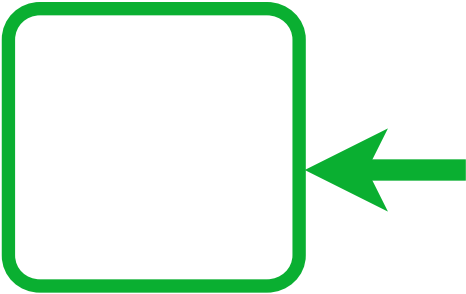


Absolute and relative paths

How do I get to the Hotel Zlatý Anděl?



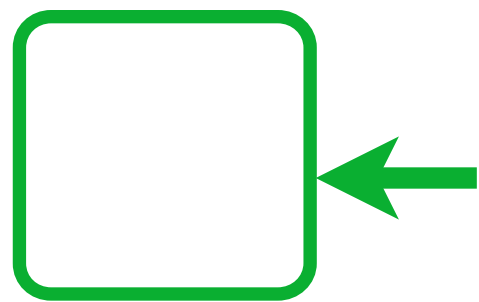
Paths



Absolute Path

`/home/catchen/working`

Relative Path?

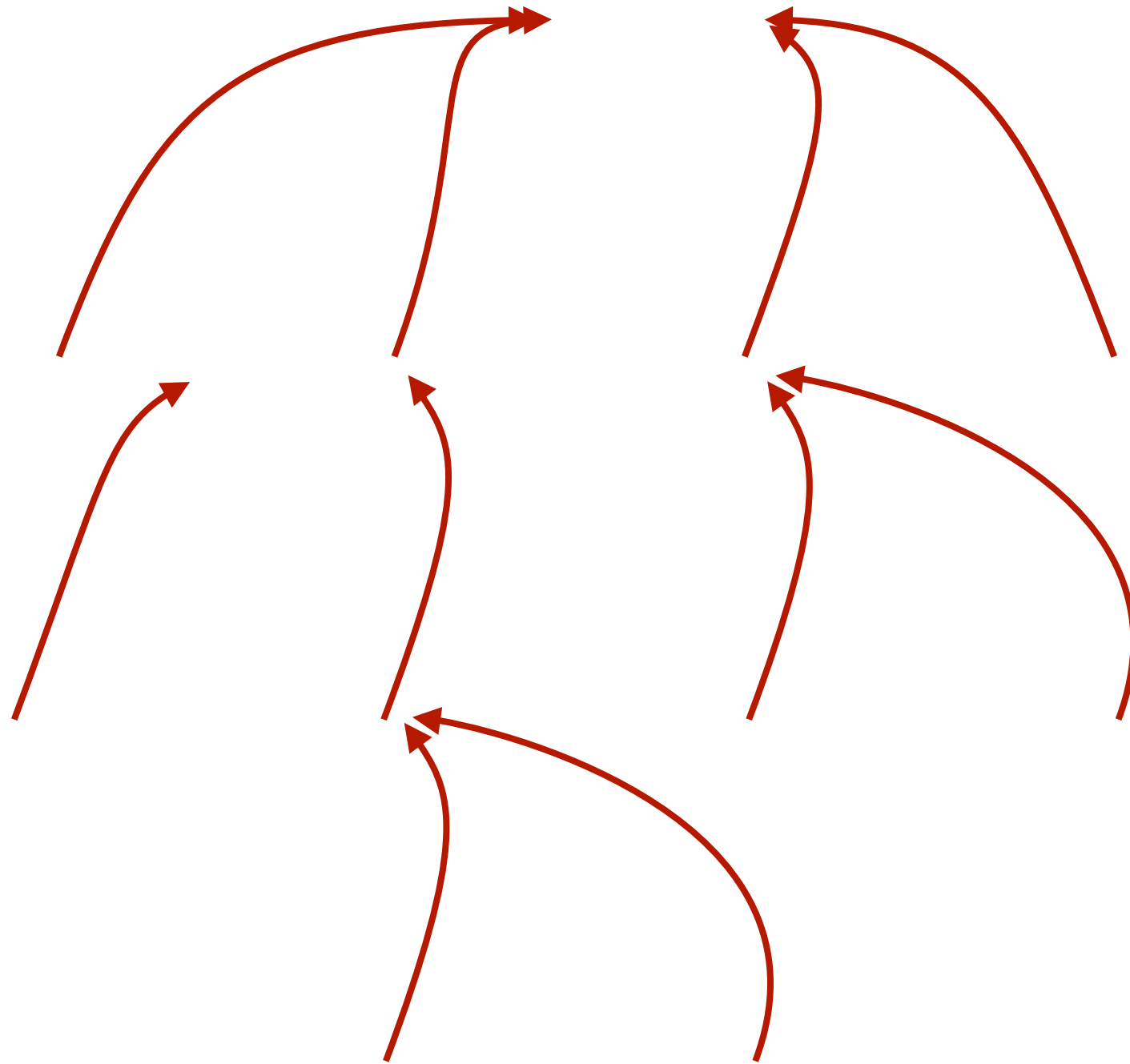


Special files -- '*dot*'

Special files -- '*dot*'

Special files -- '*dot dot*'

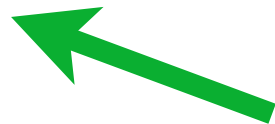
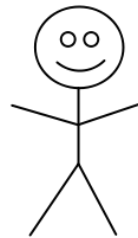
Special files -- '*dot dot*'



Relative Path

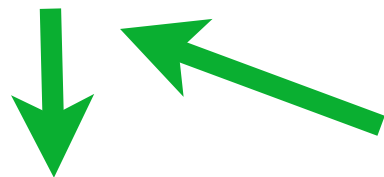
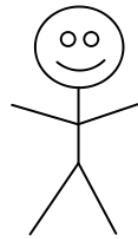


Relative Path



..

Relative Path



`../working`



Absolute Path:

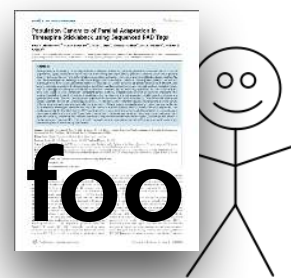
/home/catchen/working/foo

Relative Path:

../working/foo

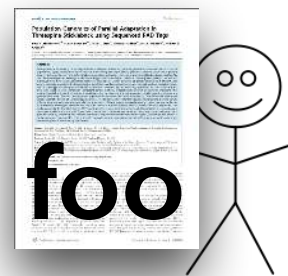


Absolute Path: **`/home/catchen/working/foo`**
Relative Path: **`../working/foo`**

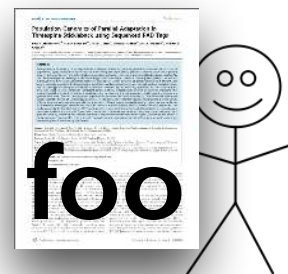


Absolute Path:

Absolute Path:



Absolute Path:
Absolute Path:



Absolute Path:

`/home/catchen/working/foo`

Absolute Path:



Absolute Path:

`/home/catchen/working/foo`

Absolute Path:

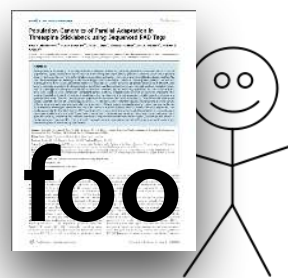


Absolute Path:

`/home/catchen/working/foo`

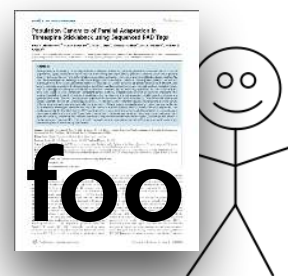
Absolute Path:

`/home/catchen/research/foo`



Relative Path:

Relative Path:



Relative Path:

Relative Path:



Relative Path:

`../working/foo`

Relative Path:



Relative Path:

`../working/foo`

Relative Path:



Relative Path:

`../working/foo`

Relative Path:

`./foo`

Absolute and relative paths

```
ubuntu@ip-10-4-193-188:~$ mkdir shell
ubuntu@ip-10-4-193-188:~$ cd shell
ubuntu@ip-10-4-193-188:~/shell$ mkdir research
ubuntu@ip-10-4-193-188:~/shell$ ls
research
ubuntu@ip-10-4-193-188:~/shell$ cd research/
ubuntu@ip-10-4-193-188:~/shell/research$ mkdir seq
ubuntu@ip-10-4-193-188:~/shell/research$ ls
seq
ubuntu@ip-10-4-193-188:~/shell/research$ cd seq/
ubuntu@ip-10-4-193-188:~/shell/research/seq$ mkdir radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq$ cd radtags/
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls -la
total 8
drwxrwxr-x 2 ubuntu ubuntu 4096 2012-03-06 23:08 .
drwxrwxr-x 3 ubuntu ubuntu 4096 2012-03-06 23:08 ..
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ pwd
/home/ubuntu/shell/research/seq/radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$
```

Special Files

dot

dot dot

Absolute and relative paths

```
ubuntu@ip-10-4-193-188:~$ mkdir shell
ubuntu@ip-10-4-193-188:~$ cd shell
ubuntu@ip-10-4-193-188:~/shell$ mkdir research
ubuntu@ip-10-4-193-188:~/shell$ ls
research
ubuntu@ip-10-4-193-188:~/shell$ cd research/
ubuntu@ip-10-4-193-188:~/shell/research$ mkdir seq
ubuntu@ip-10-4-193-188:~/shell/research$ ls
seq
ubuntu@ip-10-4-193-188:~/shell/research$ cd seq/
ubuntu@ip-10-4-193-188:~/shell/research/seq$ mkdir radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq$ cd radtags/
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ ls -la
total 8
drwxrwxr-x 2 ubuntu ubuntu 4096 2012-03-06 23:08 .
drwxrwxr-x 3 ubuntu ubuntu 4096 2012-03-06 23:08 ..
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$ pwd
/home/ubuntu/shell/research/seq/radtags
ubuntu@ip-10-4-193-188:~/shell/research/seq/radtags$
```

Special Files

dot

dot dot

% ls .

% ls ..

% ls ../../

Binary programs - ls, cp, mkdir, etc.

Binary programs - ls, cp, mkdir, etc.

```
ubuntu@ip-10-140-6-74: ~ — ssh — 133x24
ubuntu@ip-10-140-6-74:~$ ls /bin
bash      csh      getfacl  lsblk    ntfsck   readlink  true
bunzip2   dash     grep     lsmod    ntfscluster  rm      ulockmgr_server
busybox   date     gunzip   mkdir    ntfscomp  rmdir    umount
bzipcat   dbus-cleanup-sockets gzexe    mknod    ntfsdecrypt  nano    uname
bzip      dbus-daemon  gzip     mktemp   ntfsdump_logfile  run-parts  uncompress
bzdifff   dbus-uidgen  hostname  more     ntfsfix    rzsh     unicode_start
bzegrep   dd        init-checkconf  mount     ntfsinfo   sed      vdir
bzexe     df        initctl2dot  mountpoint  ntfsls    setfacl  which
bzfgrep   dir       ip         mt        ntfsmftalloc  setfont  ypdomainname
bzgrep    dmesg     kbd_mode  mt-gnu    ntfsmove    setupcon  zcat
bzip2     dnsdomainname  kill      mv        ntfstruncate  sh      zcmp
bzip2recover  domainname  ksh       nano      ntfswipe    sh.distrib  zdiff
bzless    dumpkeys   less      nc        open        sleep     zegrep
bzmored   echo       lessecho  nc.openbsd  openvt     static-sh  zfgrep
cat        ed         lessfile  netcat    pidof       stty      zforce
chacl     egrep      lesskey   netstat   ping        su        zgrep
chgrp     false     lesspipe  nisdomainname  ping6      sync      zless
chmod     fgconsole ln         loadkeys  ntfs-3g    plymouth  tailf     zmore
chown     fgrep      login     ntfs-3g.probe  plymouth-upstart-bridge  tar      znew
chvt      findmnt    lowntfs-3g  ntfs-3g.secaudit  ps        tcsh      zsh
cp        fuser     ls        ntfs-3g.usermap  pwd       tempfile  zsh4
cpio      fusermount
```

% ls /bin

Relative and absolute paths

A shortcut to your 'home', tilde:

~

Moving through the filesystem:

cd

Knowing where you are:

pwd

% ls ~/

% cd ~/

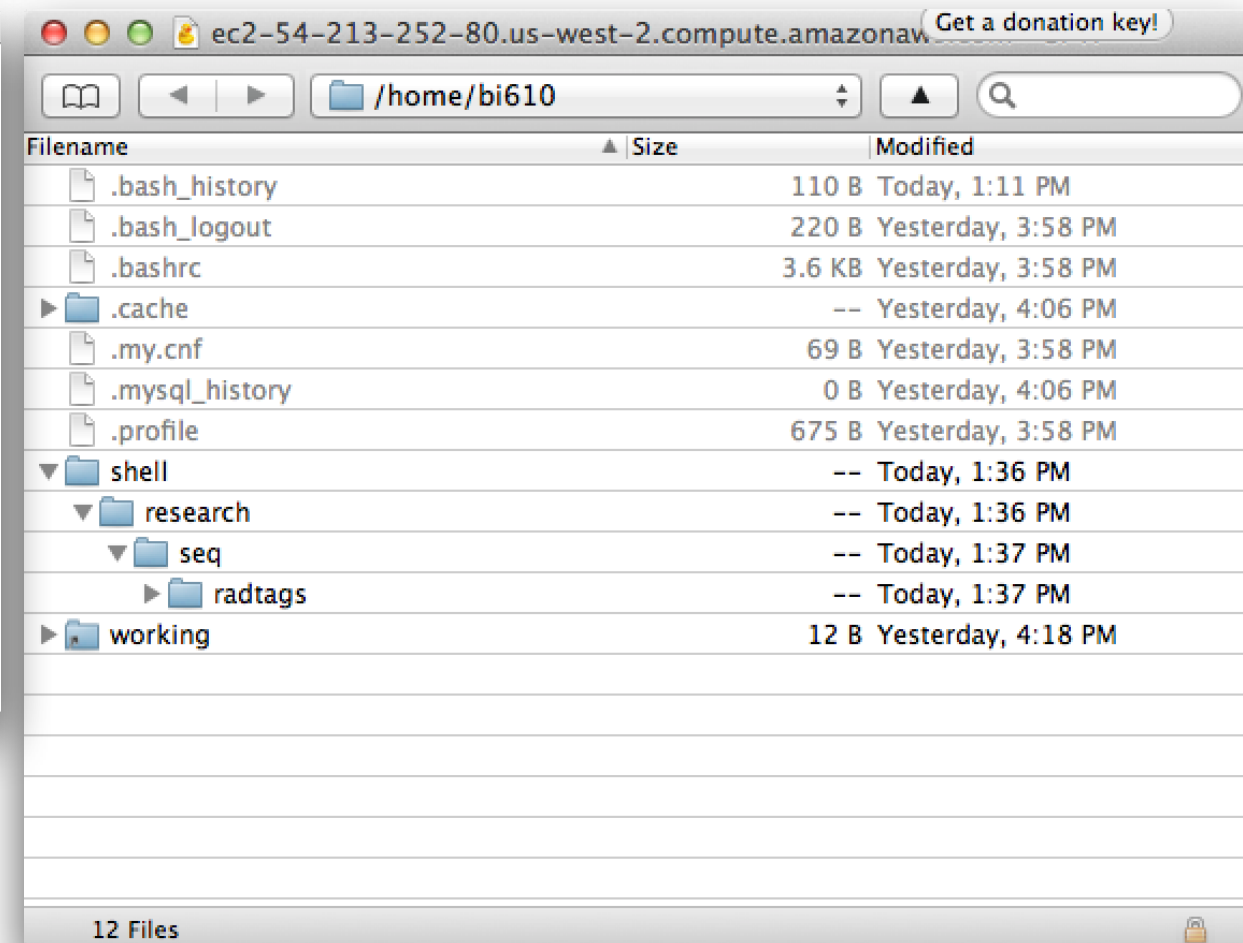
% cd

% pwd

Relative and absolute paths

/home/tgac/shell/research/seq/radtags

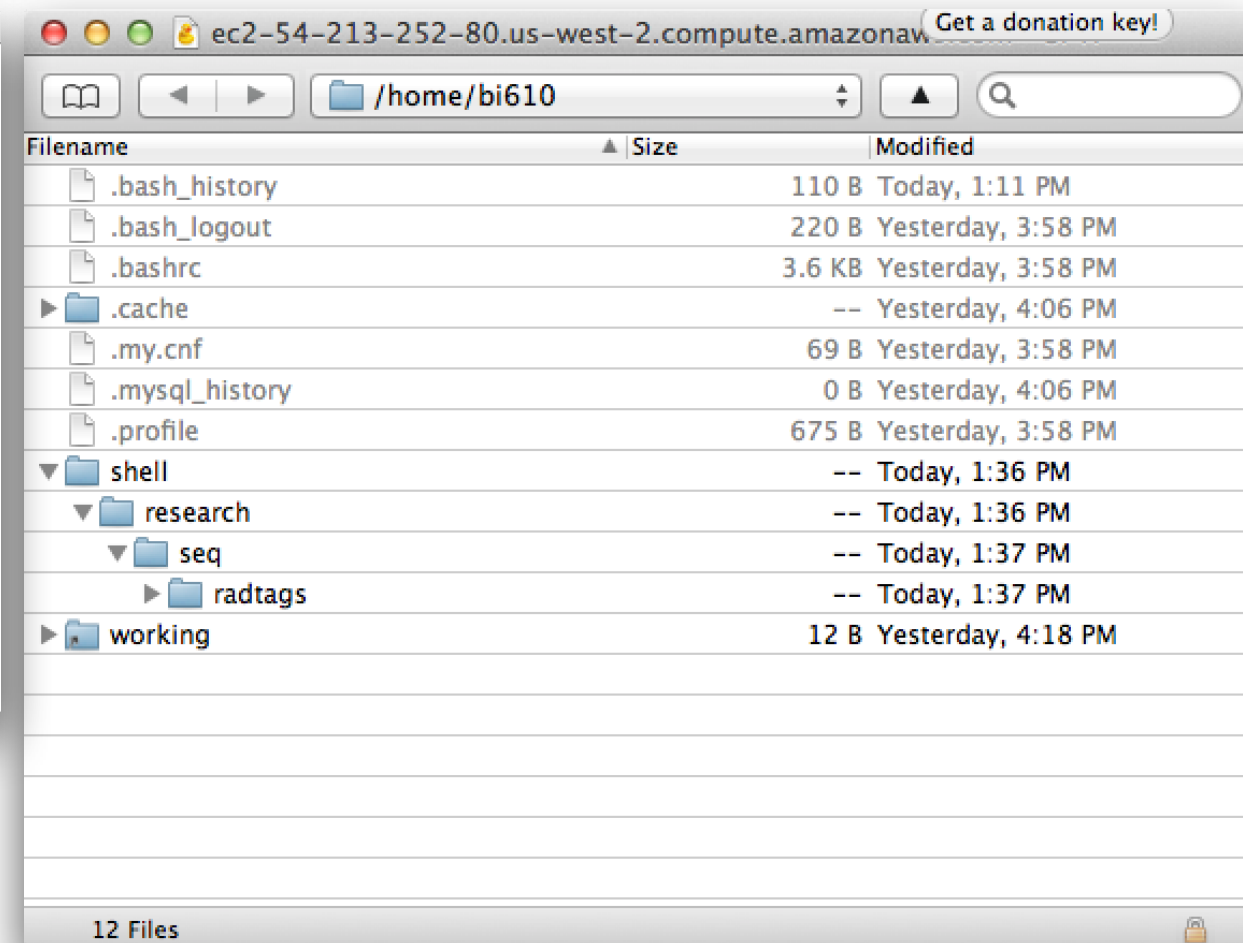
```
tgac@Genotyping2: ~/shell/research/seq/radtags — ssh — 105x23
tgac@Genotyping2:~$ mkdir shell
tgac@Genotyping2:~$ cd shell
tgac@Genotyping2:~/shell$ mkdir research
tgac@Genotyping2:~/shell$ ls
research
tgac@Genotyping2:~/shell$ cd research/
tgac@Genotyping2:~/shell/research$ mkdir seq
tgac@Genotyping2:~/shell/research$ ls
seq
tgac@Genotyping2:~/shell/research$ cd seq/
tgac@Genotyping2:~/shell/research/seq$ ls
tgac@Genotyping2:~/shell/research/seq$ mkdir radtags
tgac@Genotyping2:~/shell/research/seq$ ls
radtags
tgac@Genotyping2:~/shell/research/seq$ ls -la
total 12
drwxrwxr-x 3 tgac tgac 4096 Nov  4 09:34 .
drwxrwxr-x 3 tgac tgac 4096 Nov  4 09:34 ..
drwxrwxr-x 2 tgac tgac 4096 Nov  4 09:34 radtags
tgac@Genotyping2:~/shell/research/seq$ cd radtags/
tgac@Genotyping2:~/shell/research/seq/radtags$ pwd
/home/tgac/shell/research/seq/radtags
tgac@Genotyping2:~/shell/research/seq/radtags$
```



Relative and absolute paths

/home/tgac/shell/research/seq/radtags

```
tgac@Genotyping2: ~/shell/research/seq/radtags — ssh — 105x23
tgac@Genotyping2:~$ mkdir shell
tgac@Genotyping2:~$ cd shell
tgac@Genotyping2:~/shell$ mkdir research
tgac@Genotyping2:~/shell$ ls
research
tgac@Genotyping2:~/shell$ cd research/
tgac@Genotyping2:~/shell/research$ mkdir seq
tgac@Genotyping2:~/shell/research$ ls
seq
tgac@Genotyping2:~/shell/research$ cd seq/
tgac@Genotyping2:~/shell/research/seq$ ls
tgac@Genotyping2:~/shell/research/seq$ mkdir radtags
tgac@Genotyping2:~/shell/research/seq$ ls
radtags
tgac@Genotyping2:~/shell/research/seq$ ls -la
total 12
drwxrwxr-x 3 tgac tgac 4096 Nov  4 09:34 .
drwxrwxr-x 3 tgac tgac 4096 Nov  4 09:34 ..
drwxrwxr-x 2 tgac tgac 4096 Nov  4 09:34 radtags
tgac@Genotyping2:~/shell/research/seq$ cd radtags/
tgac@Genotyping2:~/shell/research/seq/radtags$ pwd
/home/tgac/shell/research/seq/radtags
tgac@Genotyping2:~/shell/research/seq/radtags$
```



% ls .

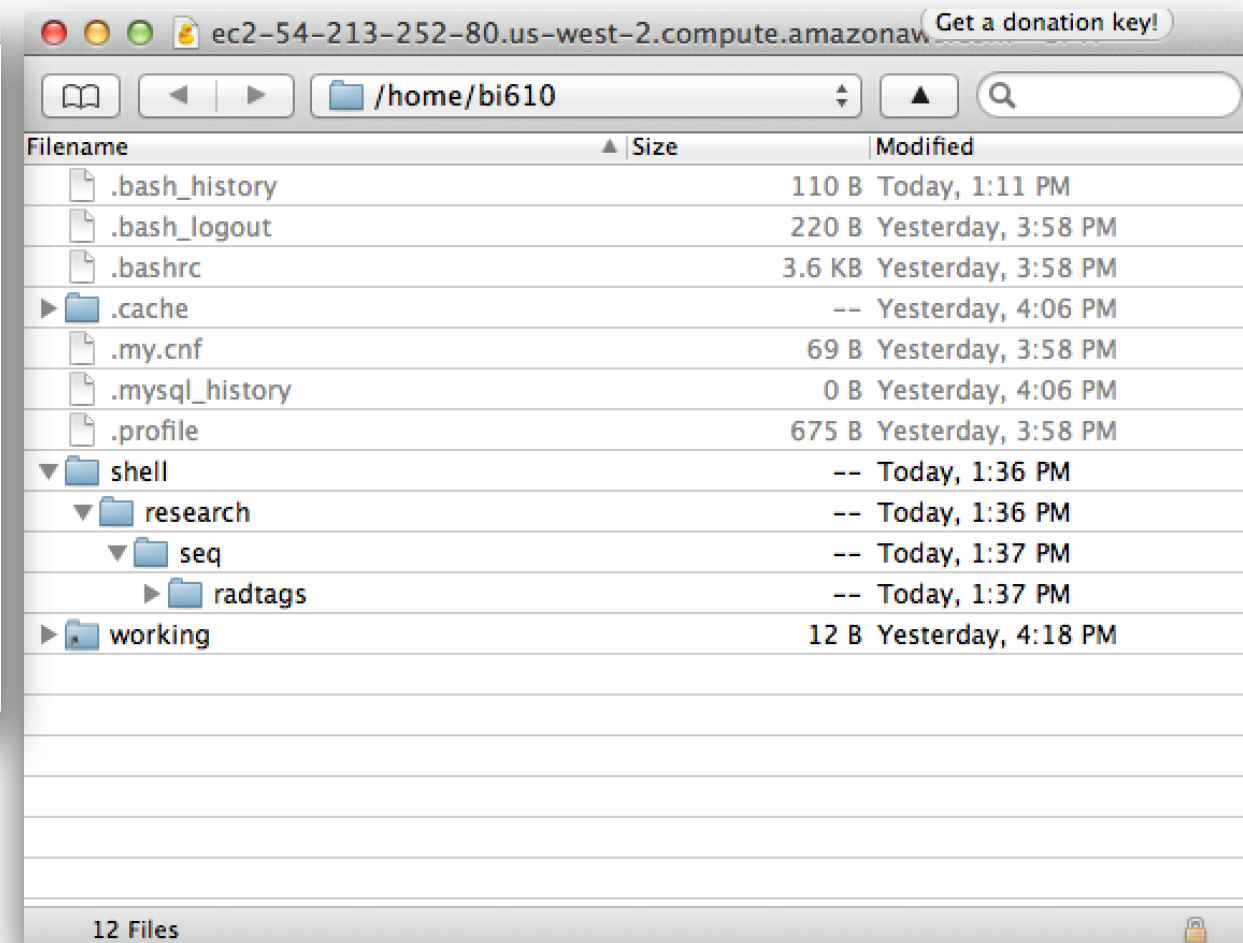
% ls ..

% ls ../../

Relative and absolute paths

/home/tgac/shell/research/seq/radtags

```
tgac@Genotyping2: ~/shell/research/seq/radtags — ssh — 105x23
tgac@Genotyping2:~$ mkdir shell
tgac@Genotyping2:~$ cd shell
tgac@Genotyping2:~/shell$ mkdir research
tgac@Genotyping2:~/shell$ ls
research
tgac@Genotyping2:~/shell$ cd research/
tgac@Genotyping2:~/shell/research$ mkdir seq
tgac@Genotyping2:~/shell/research$ ls
seq
tgac@Genotyping2:~/shell/research$ cd seq/
tgac@Genotyping2:~/shell/research/seq$ ls
tgac@Genotyping2:~/shell/research/seq$ mkdir radtags
tgac@Genotyping2:~/shell/research/seq$ ls
radtags
tgac@Genotyping2:~/shell/research/seq$ ls -la
total 12
drwxrwxr-x 3 tgac tgac 4096 Nov  4 09:34 .
drwxrwxr-x 3 tgac tgac 4096 Nov  4 09:34 ..
drwxrwxr-x 2 tgac tgac 4096 Nov  4 09:34 radtags
tgac@Genotyping2:~/shell/research/seq$ cd radtags/
tgac@Genotyping2:~/shell/research/seq/radtags$ pwd
/home/tgac/shell/research/seq/radtags
tgac@Genotyping2:~/shell/research/seq/radtags$
```



% ls .

% ls ..

% ls ../../

% cd ~/

% cd shell/research

% pwd

Are you typing? You're doing it wrong.

Tab-completion:

- Tab once to complete uniquely
- Tab twice to see all possible completions

Up-arrow:

- Previous commands can be found by pressing “up-arrow”

‘history’

```
bi610@ip-172-31-17-121: /etc — ssh — 92x40
bi610@ip-172-31-17-121:~/shell/research/seq/radtags$ cd /etc/
bi610@ip-172-31-17-121:/etc$ ls -l
total 868
-rw-r--r-- 1 root root 15070 Apr  4 04:30 a2ps.cfg
-rw-r--r-- 1 root root 2563 Apr  4 04:30 a2ps-site.cfg
drwxr-xr-x 3 root root 4096 Apr 16 18:26 acpi
-rw-r--r-- 1 root root 2981 Apr 16 18:25 adduser.conf
-rw-r--r-- 1 root root 10 Apr 16 18:27 adjtime
drwxr-xr-x 2 root root 4096 Jun 20 22:23 alternatives
drwxr-xr-x 8 root root 4096 Jun 20 21:30 apache2
drwxr-xr-x 3 root root 4096 Apr 16 18:25 apm
drwxr-xr-x 3 root root 4096 Apr 16 18:26 apparmor
drwxr-xr-x 8 root root 4096 Jun 19 22:10 apparmor.d
drwxr-xr-x 3 root root 4096 Jun 19 22:00 appport
drwxr-xr-x 6 root root 4096 Apr 16 18:27 apt
-rw-r----- 1 root daemon 144 Oct 21 2013 at.deny
-rw-r--r-- 1 root root 2177 Apr  9 01:03 bash.bashrc
-rw-r--r-- 1 root root 45 Mar 22 20:57 bash_completion
drwxr-xr-x 2 root root 4096 Jun 20 21:44 bash_completion.d
-rw-r--r-- 1 root root 356 Jan  1 2012 bindresvport.blacklist
-rw-r--r-- 1 root root 321 Apr 16 16:07 blkid.conf
lrwxrwxrwx 1 root root 15 Jun  3 20:54 blkid.tab -> /dev/.blkid.tab
drwxr-xr-x 2 root root 4096 Apr 16 18:26 byobu
drwxr-xr-x 3 root root 4096 Apr 16 18:25 ca-certificates
-rw-r--r-- 1 root root 7464 Apr 16 18:26 ca-certificates.conf
drwxr-xr-x 2 root root 4096 Apr 16 18:26 calendar
drwxr-s--- 2 root dip 4096 Apr 16 18:26 chatscripts
drwxr-xr-x 4 root root 4096 Apr 16 18:27 cloud
drwxr-xr-x 2 root root 4096 Apr 16 18:25 console-setup
drwxr-xr-x 2 root root 4096 Jun 19 22:10 cron.d
drwxr-xr-x 2 root root 4096 Jun 19 22:10 cron.daily
drwxr-xr-x 2 root root 4096 Apr 16 18:25 cron.hourly
drwxr-xr-x 2 root root 4096 Apr 16 18:25 cron.monthly
-rw-r--r-- 1 root root 722 Feb  9 2013 crontab
drwxr-xr-x 2 root root 4096 Jun 20 22:23 cron.weekly
-rw-r--r-- 1 root root 54 Apr 16 18:26 crypttab
drwxr-xr-x 4 root root 4096 Apr 16 18:26 dbus-1
-rw-r--r-- 1 root root 2969 Feb 23 14:30 debconf.conf
-rw-r--r-- 1 root root 11 Feb 20 02:43 debian_version
drwxr-xr-x 3 root root 4096 Jun 20 22:23 default
```


Are you typing? You're doing it wrong.

Tab-completion:

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- Tab twice to see all possible completions

Up-arrow:

- Previous commands can be found by pressing “up-arrow”

‘history’

```
bi610@ip-172-31-17-121: /etc — ssh — 92x40
bi610@ip-172-31-17-121:~/shell/research/seq/radtags$ cd /etc/
bi610@ip-172-31-17-121:/etc$ ls -l
total 868
-rw-r--r-- 1 root root 15070 Apr  4 04:30 a2ps.cfg
-rw-r--r-- 1 root root 2563 Apr  4 04:30 a2ps-site.cfg
drwxr-xr-x 3 root root 4096 Apr 16 18:26 acpi
-rw-r--r-- 1 root root 2981 Apr 16 18:25 adduser.conf
-rw-r--r-- 1 root root 10 Apr 16 18:27 adjtime
drwxr-xr-x 2 root root 4096 Jun 20 22:23 alternatives
drwxr-xr-x 8 root root 4096 Jun 20 21:30 apache2
drwxr-xr-x 3 root root 4096 Apr 16 18:25 apm
drwxr-xr-x 3 root root 4096 Apr 16 18:26 apparmor
drwxr-xr-x 8 root root 4096 Jun 19 22:10 apparmor.d
drwxr-xr-x 3 root root 4096 Jun 19 22:00 appport
drwxr-xr-x 6 root root 4096 Apr 16 18:27 apt
-rw-r----- 1 root daemon 144 Oct 21 2013 at.deny
-rw-r--r-- 1 root root 2177 Apr  9 01:03 bash.bashrc
-rw-r--r-- 1 root root 45 Mar 22 20:57 bash_completion
drwxr-xr-x 2 root root 4096 Jun 20 21:44 bash_completion.d
-rw-r--r-- 1 root root 356 Jan  1 2012 bindresvport.blacklist
-rw-r--r-- 1 root root 321 Apr 16 16:07 blkid.conf
lrwxrwxrwx 1 root root 15 Jun  3 20:54 blkid.tab -> /dev/.blkid.tab
drwxr-xr-x 2 root root 4096 Apr 16 18:26 byobu
drwxr-xr-x 3 root root 4096 Apr 16 18:25 ca-certificates
-rw-r--r-- 1 root root 7464 Apr 16 18:26 ca-certificates.conf
drwxr-xr-x 2 root root 4096 Apr 16 18:26 calendar
drwxr-s--- 2 root dip 4096 Apr 16 18:26 chatscripts
drwxr-xr-x 4 root root 4096 Apr 16 18:27 cloud
drwxr-xr-x 2 root root 4096 Apr 16 18:25 console-setup
drwxr-xr-x 2 root root 4096 Jun 19 22:10 cron.d
drwxr-xr-x 2 root root 4096 Jun 19 22:10 cron.daily
drwxr-xr-x 2 root root 4096 Apr 16 18:25 cron.hourly
drwxr-xr-x 2 root root 4096 Apr 16 18:25 cron.monthly
-rw-r--r-- 1 root root 722 Feb  9 2013 crontab
drwxr-xr-x 2 root root 4096 Jun 20 22:23 cron.weekly
-rw-r--r-- 1 root root 54 Apr 16 18:26 crypttab
drwxr-xr-x 4 root root 4096 Apr 16 18:26 dbus-1
-rw-r--r-- 1 root root 2969 Feb 23 14:30 debconf.conf
-rw-r--r-- 1 root root 11 Feb 20 02:43 debian_version
drwxr-xr-x 3 root root 4096 Jun 20 22:23 default
```

```
% ls c <tab>
```

```
% ls c <tab><tab>
```


Are you typing? You're doing it wrong.

Tab-completion:

- Tab once to complete uniquely
- Tab twice to see all possible completions

Up-arrow:

- Previous commands can be found by pressing “up-arrow”

‘history’

```
% cd /etc
```

```
% ls c <tab>
```

```
% pwd
```

```
% ls c <tab><tab>
```

```
bi610@ip-172-31-17-121: /etc — ssh — 92x40
bi610@ip-172-31-17-121:~/shell/research/seq/radtags$ cd /etc/
bi610@ip-172-31-17-121:/etc$ ls -l
total 868
-rw-r--r-- 1 root root 15070 Apr  4 04:30 a2ps.cfg
-rw-r--r-- 1 root root 2563 Apr  4 04:30 a2ps-site.cfg
drwxr-xr-x 3 root root 4096 Apr 16 18:26 acpi
-rw-r--r-- 1 root root 2981 Apr 16 18:25 adduser.conf
-rw-r--r-- 1 root root 10 Apr 16 18:27 adjtime
drwxr-xr-x 2 root root 4096 Jun 20 22:23 alternatives
drwxr-xr-x 8 root root 4096 Jun 20 21:30 apache2
drwxr-xr-x 3 root root 4096 Apr 16 18:25 apm
drwxr-xr-x 3 root root 4096 Apr 16 18:26 apparmor
drwxr-xr-x 8 root root 4096 Jun 19 22:10 apparmor.d
drwxr-xr-x 3 root root 4096 Jun 19 22:00 appport
drwxr-xr-x 6 root root 4096 Apr 16 18:27 apt
-rw-r----- 1 root daemon 144 Oct 21 2013 at.deny
-rw-r--r-- 1 root root 2177 Apr  9 01:03 bash.bashrc
-rw-r--r-- 1 root root 45 Mar 22 20:57 bash_completion
drwxr-xr-x 2 root root 4096 Jun 20 21:44 bash_completion.d
-rw-r--r-- 1 root root 356 Jan  1 2012 bindresvport.blacklist
-rw-r--r-- 1 root root 321 Apr 16 16:07 blkid.conf
lrwxrwxrwx 1 root root 15 Jun  3 20:54 blkid.tab -> /dev/.blkid.tab
drwxr-xr-x 2 root root 4096 Apr 16 18:26 byobu
drwxr-xr-x 3 root root 4096 Apr 16 18:25 ca-certificates
-rw-r--r-- 1 root root 7464 Apr 16 18:26 ca-certificates.conf
drwxr-xr-x 2 root root 4096 Apr 16 18:26 calendar
drwxr-s--- 2 root dip 4096 Apr 16 18:26 chatscripts
drwxr-xr-x 4 root root 4096 Apr 16 18:27 cloud
drwxr-xr-x 2 root root 4096 Apr 16 18:25 console-setup
drwxr-xr-x 2 root root 4096 Jun 19 22:10 cron.d
drwxr-xr-x 2 root root 4096 Jun 19 22:10 cron.daily
drwxr-xr-x 2 root root 4096 Apr 16 18:25 cron.hourly
drwxr-xr-x 2 root root 4096 Apr 16 18:25 cron.monthly
-rw-r--r-- 1 root root 722 Feb  9 2013 crontab
drwxr-xr-x 2 root root 4096 Jun 20 22:23 cron.weekly
-rw-r--r-- 1 root root 54 Apr 16 18:26 crypttab
drwxr-xr-x 4 root root 4096 Apr 16 18:26 dbus-1
-rw-r--r-- 1 root root 2969 Feb 23 14:30 debconf.conf
-rw-r--r-- 1 root root 11 Feb 20 02:43 debian_version
drwxr-xr-x 3 root root 4096 Jun 20 22:23 default
```

Three variants to ls

```
ls -l
```

provides a *long*
listing

```
ls -la
```

includes *all* files,
even hidden files

```
ls -lh
```

displays file sizes
in *human* readable
numbers

Four ways to view a text file

<code>more</code>	<code>head</code>	<code>tail</code>	<code>cat</code>
view a text file one screen full at a time	view the top 15 lines of a file	view the last 15 lines of a file	spit the whole file at once
space-bar: scroll q: quit	-n num controls the number of lines	-n num controls the number of lines	

Explore the file hierarchy

1. Move to the directory `/etc`

- What is the first line of the file `hosts` in the directory `/etc`?
- What is the relative file path to get to `/var/log` from here?
- What is the absolute path?

2. Move to the directory `/var/log/`

- What is the contents on line 73 of the `dmesg` file?
- Without changing directories, what is the second line of the `cpuinfo` file in the `proc` directory?
 - What is the command to read this file with a relative path?
 - An absolute path?

3. Move back to the root, what directories do you see?

4. Move back home, what are three ways to move home from the root?

Copy example files

Return to the directory in your home called 'shell'.

TSV file:

`~/workshop_data/unix/batch_1.genotypes_1.loc.gz`

FASTQ file:

`~/workshop_data/unix/s_1_sequence.txt.gz`

Tar Archive:

`~/workshop_data/unix/samples.tar.gz`

What is a tar archive?



tar = tape archive

Compress / Decompress

`gzip / gunzip`

`batch_l.genotypes_l.loc.gz`

`s_l_sequence.txt.gz`

Gzipped Tar archive

`tar xvfz`

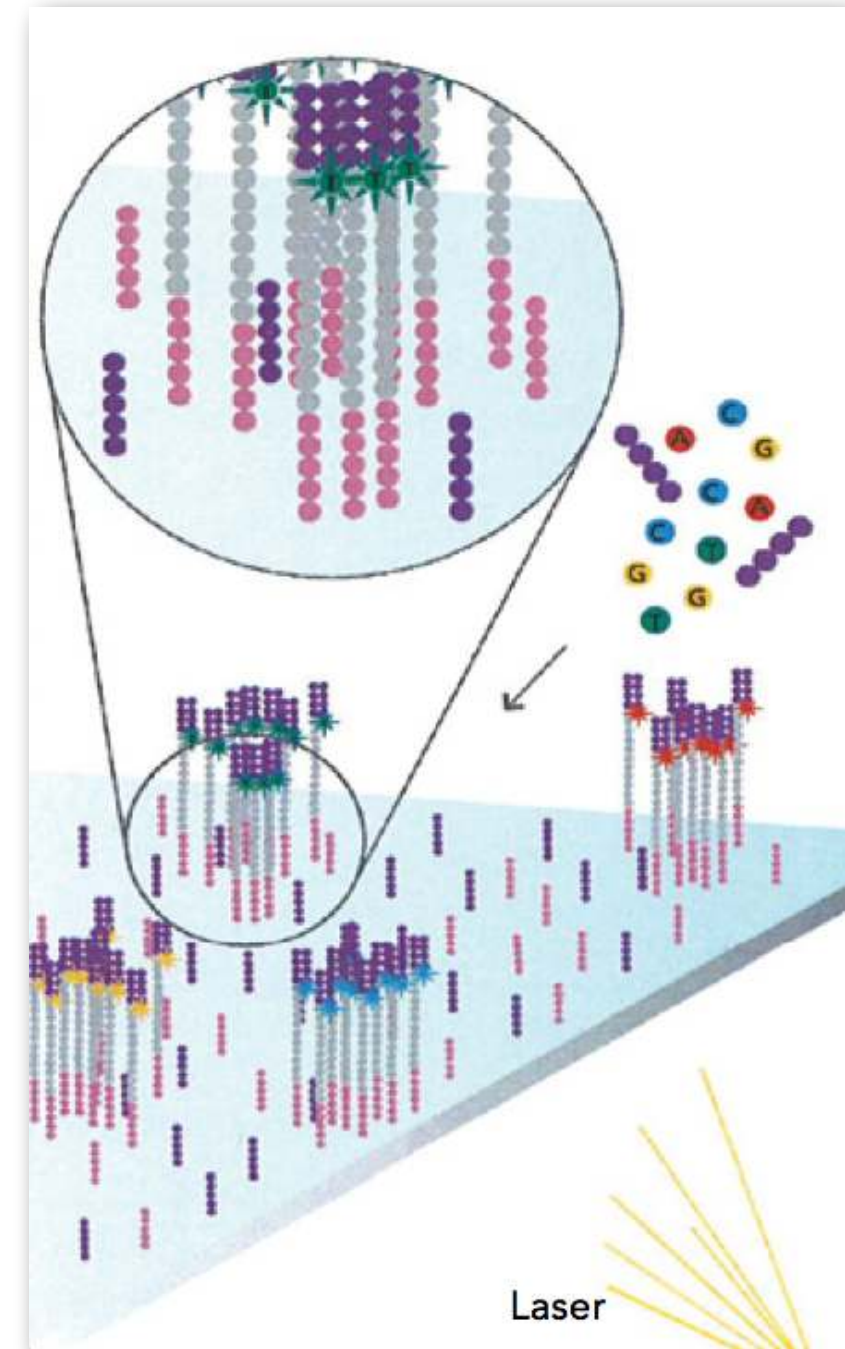
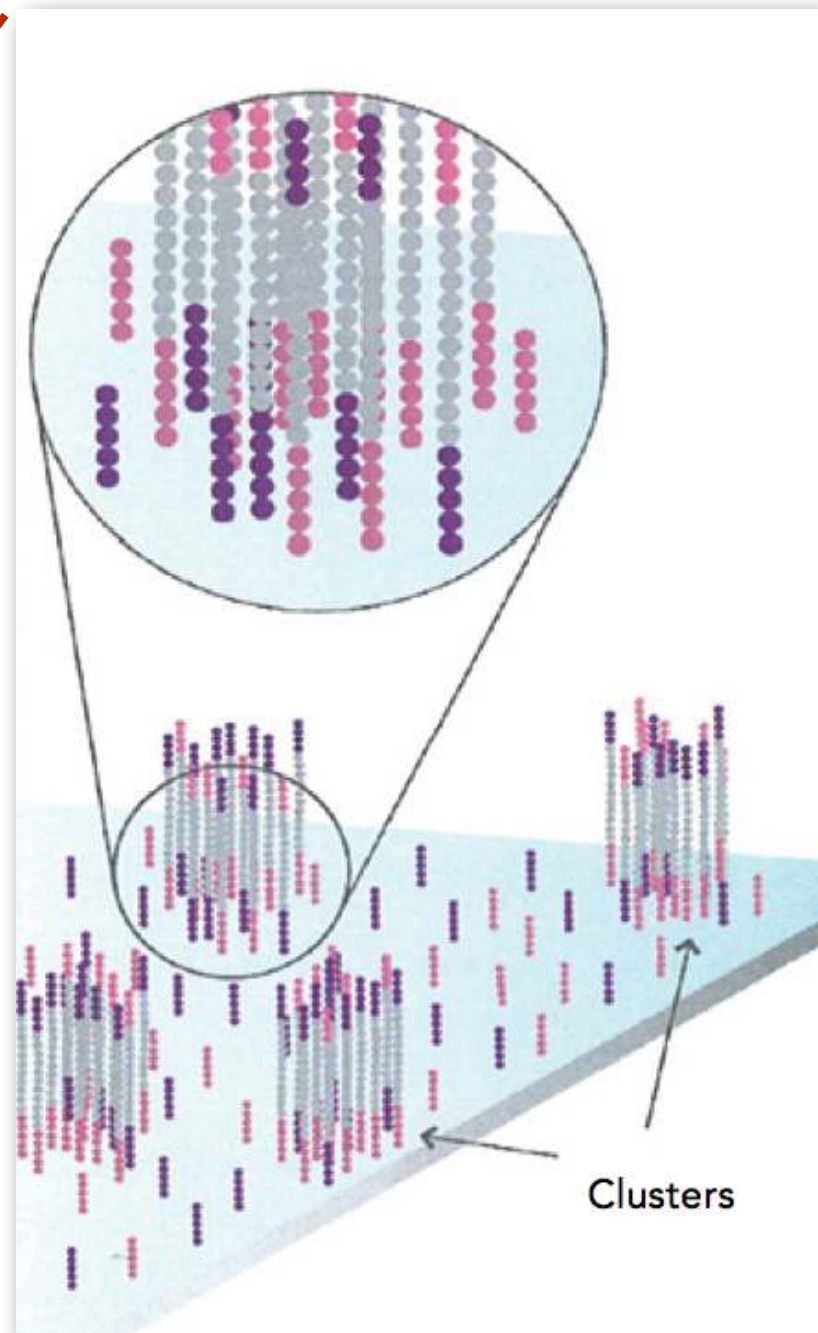
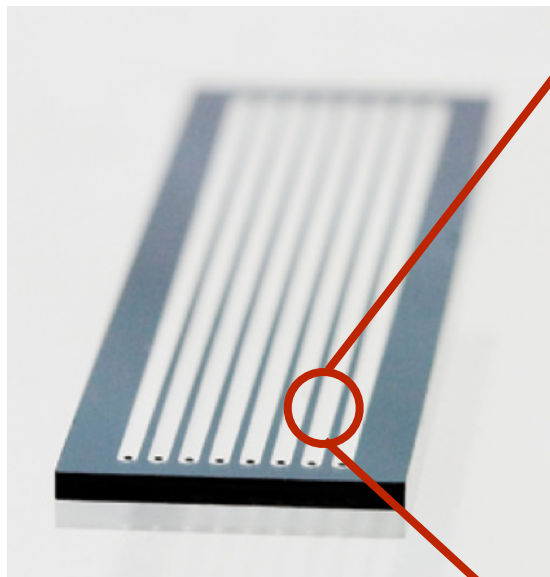
`samples.tar.gz`

Tar archive

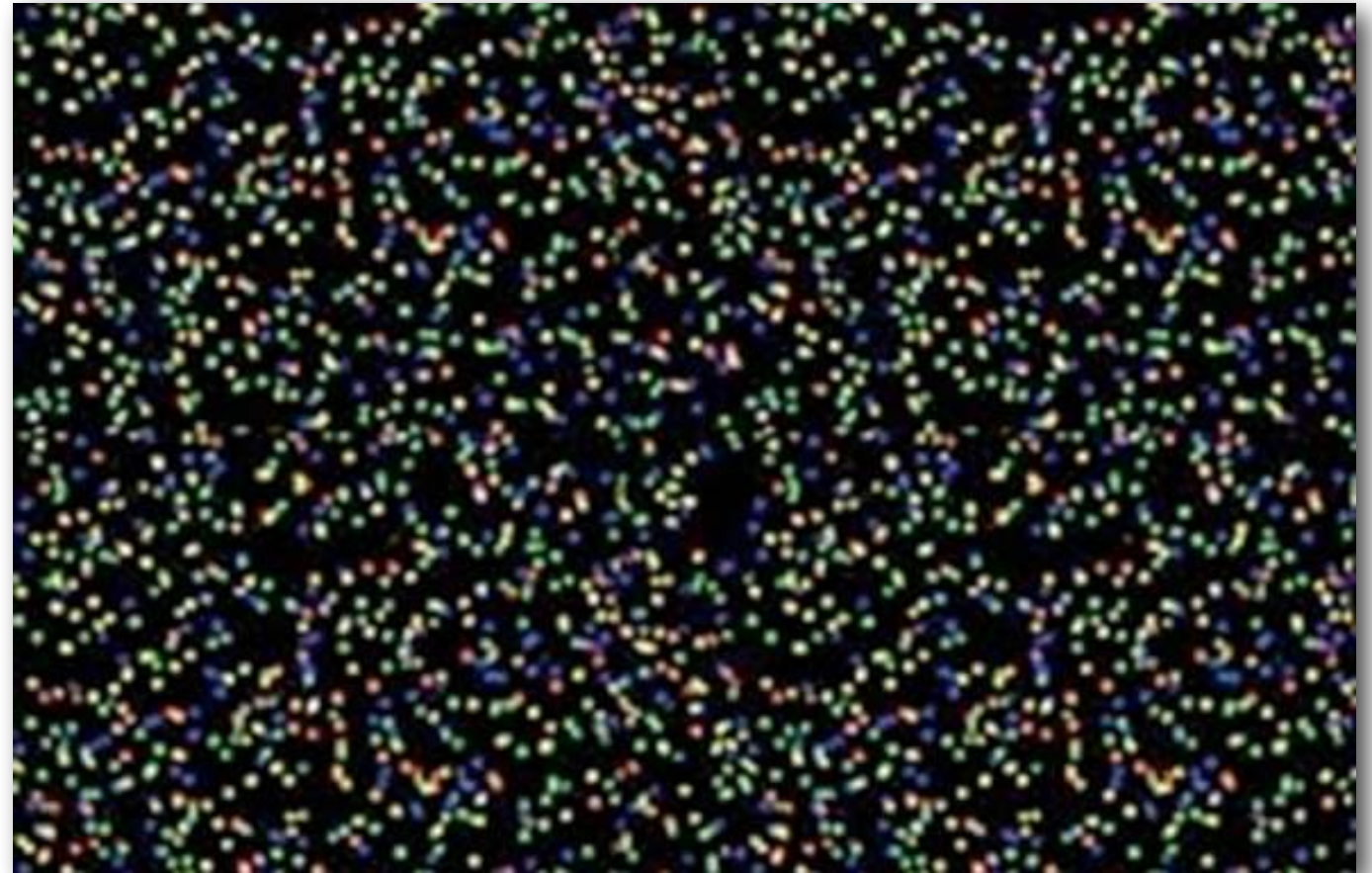
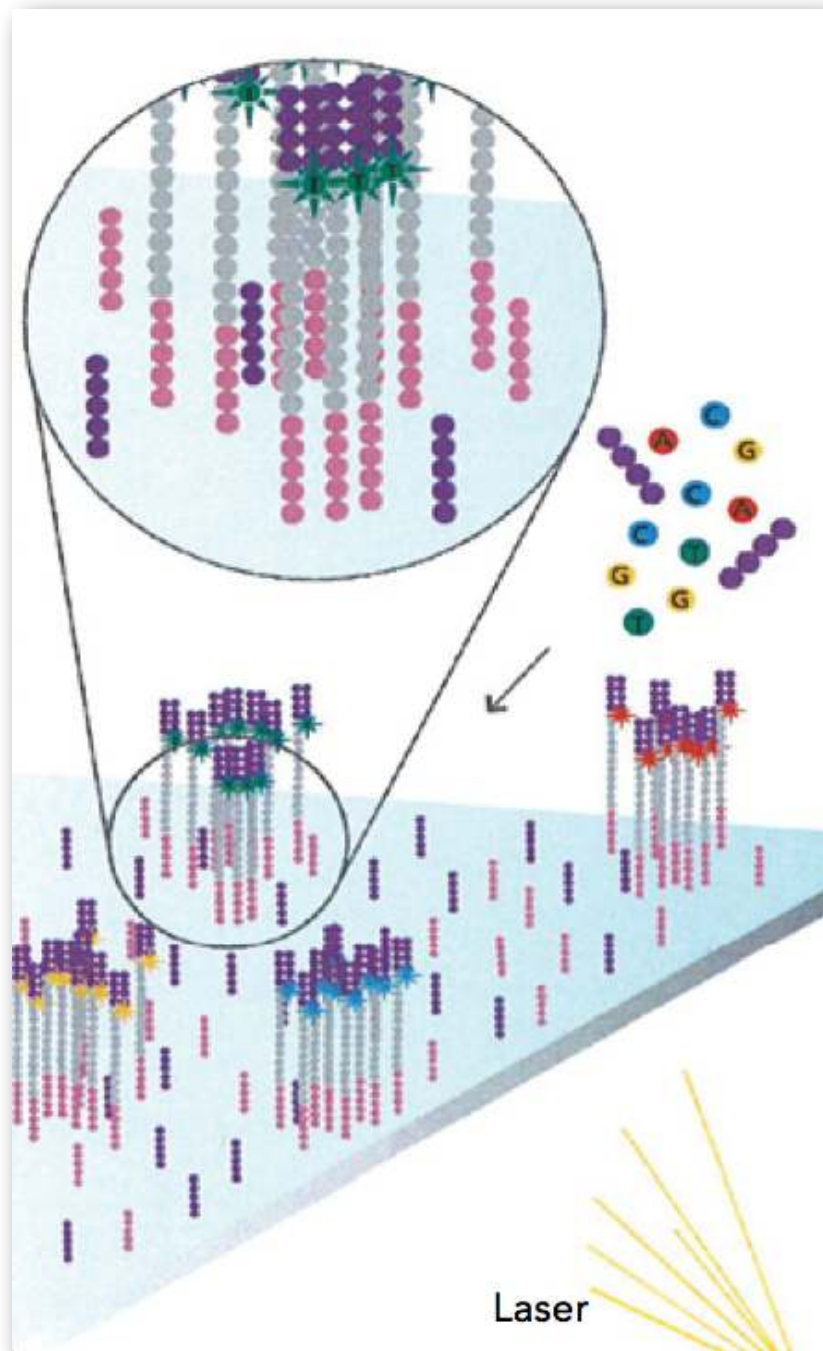
`tar xvf`

`samples.tar`

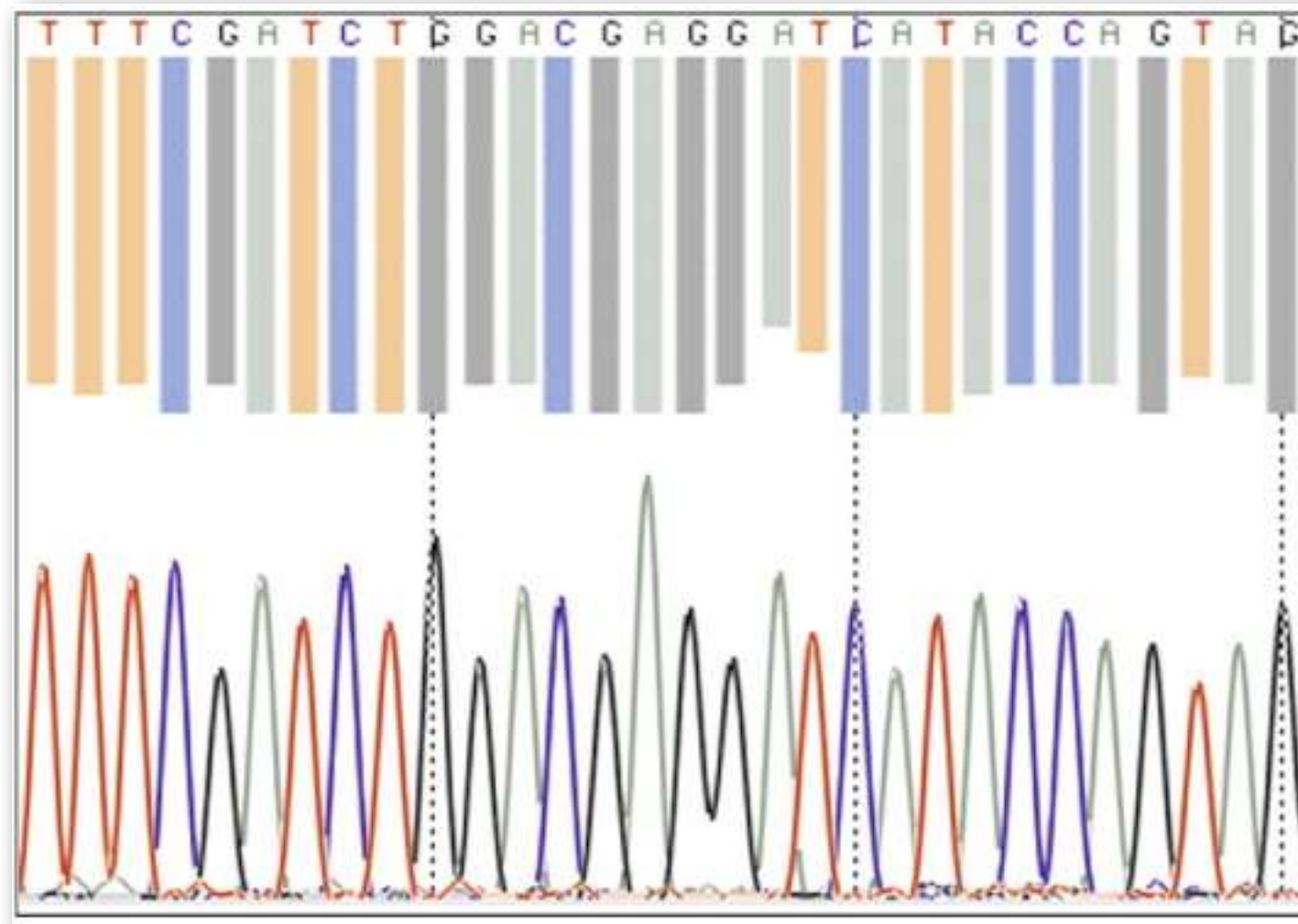
Sequencing on Illumina's Flow cell



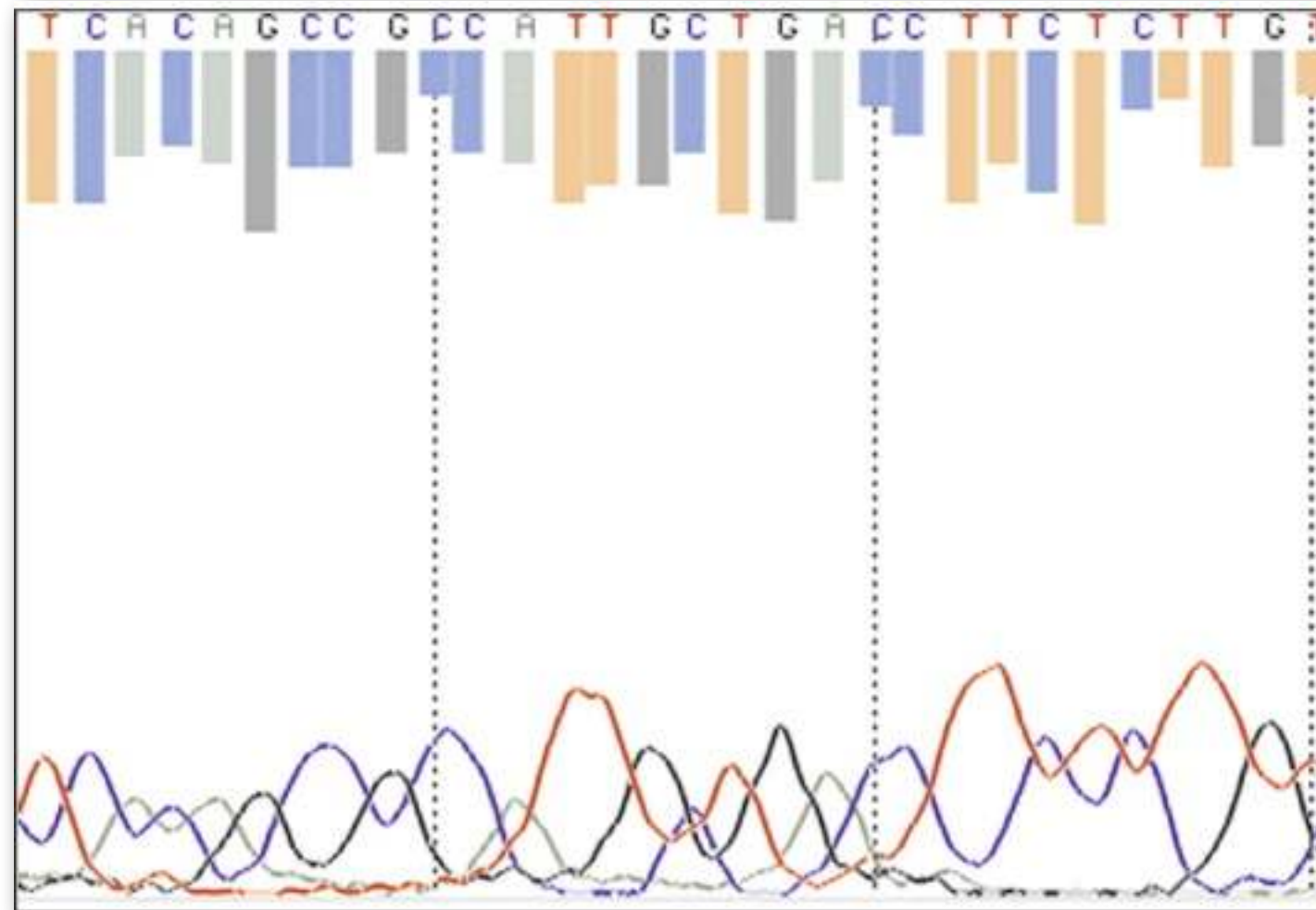
Sequencing on Illumina's Flow cell, ctd.



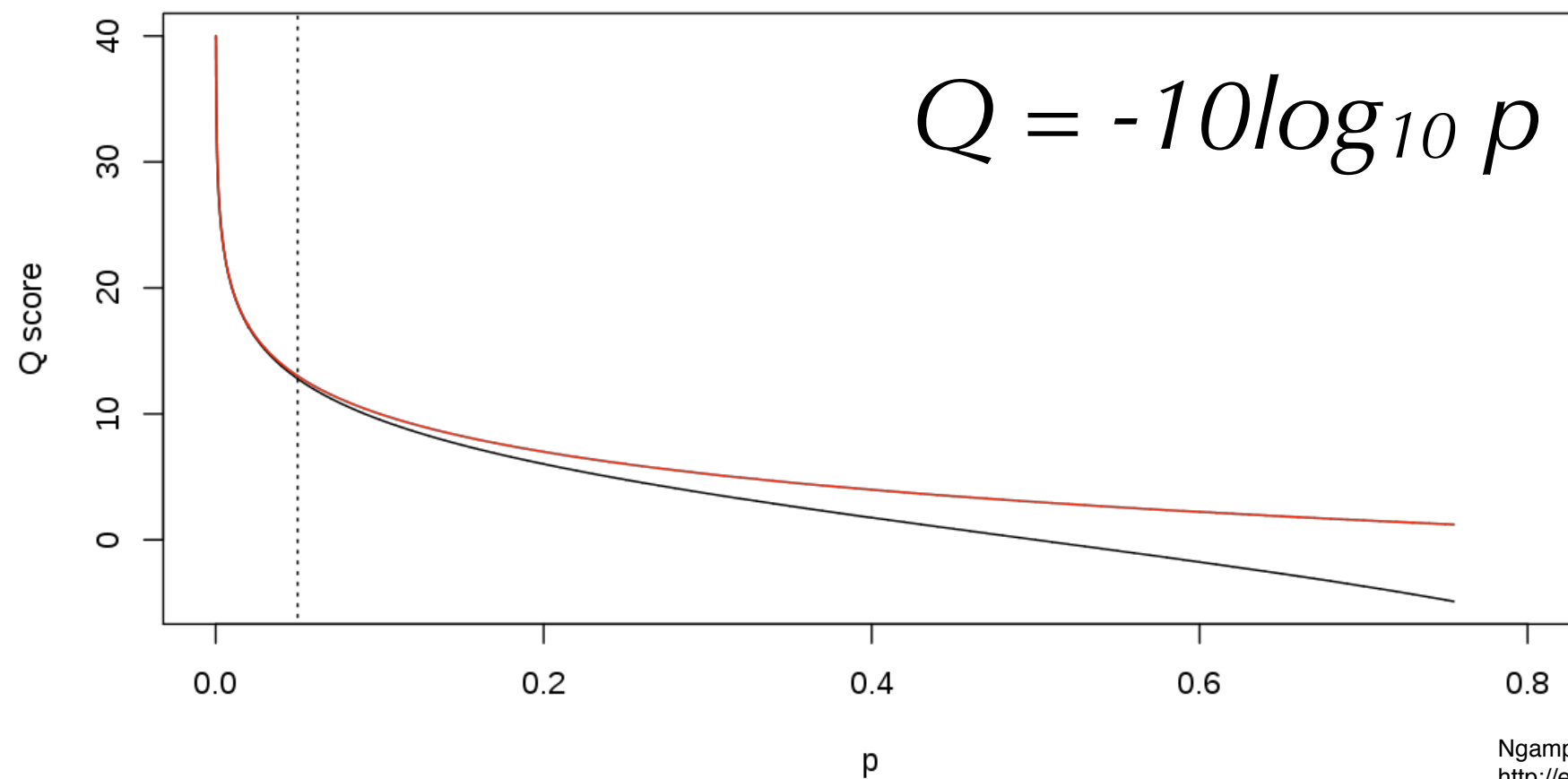
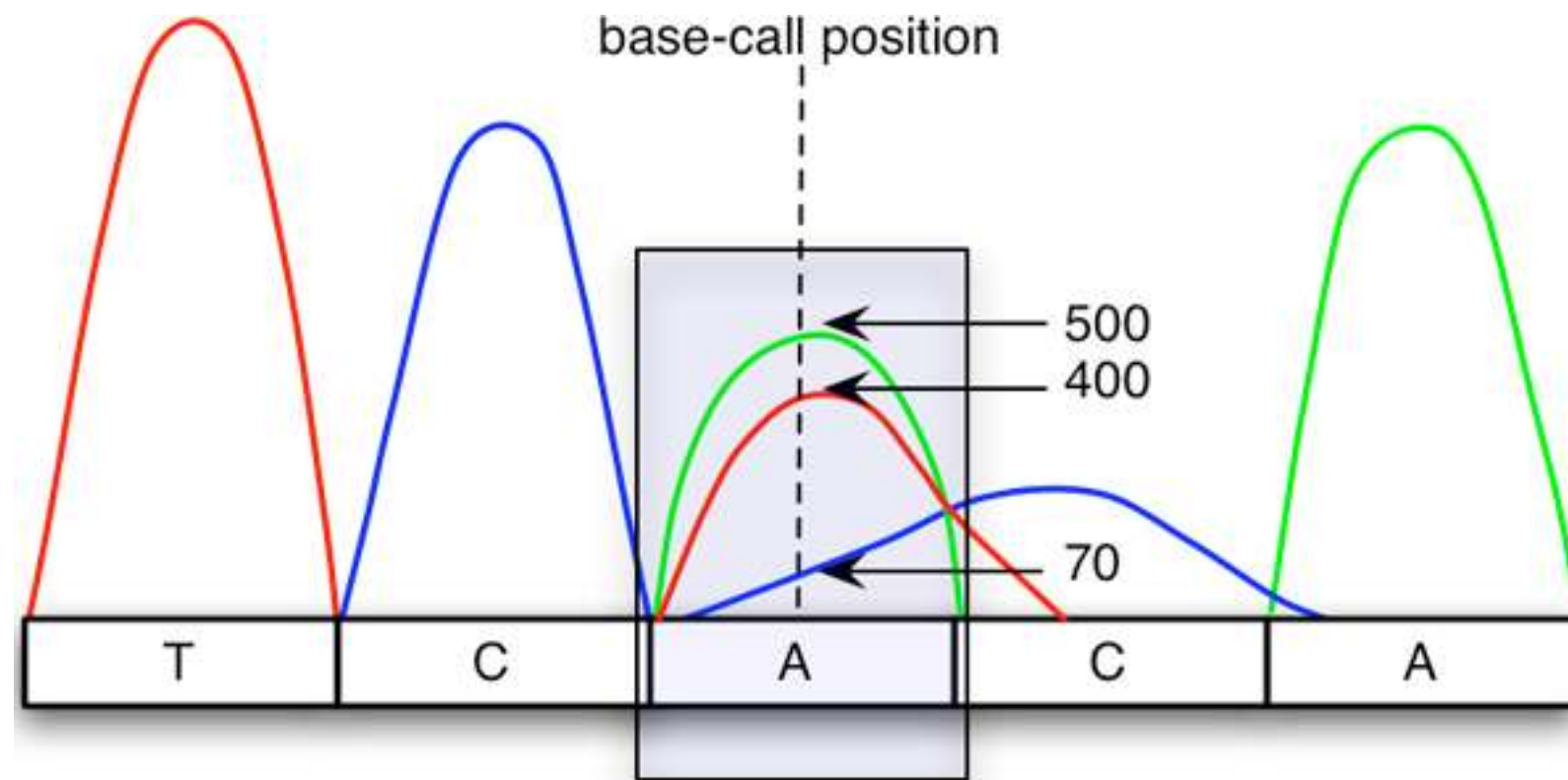
Sequencing on Illumina's Flow cell, ctd.



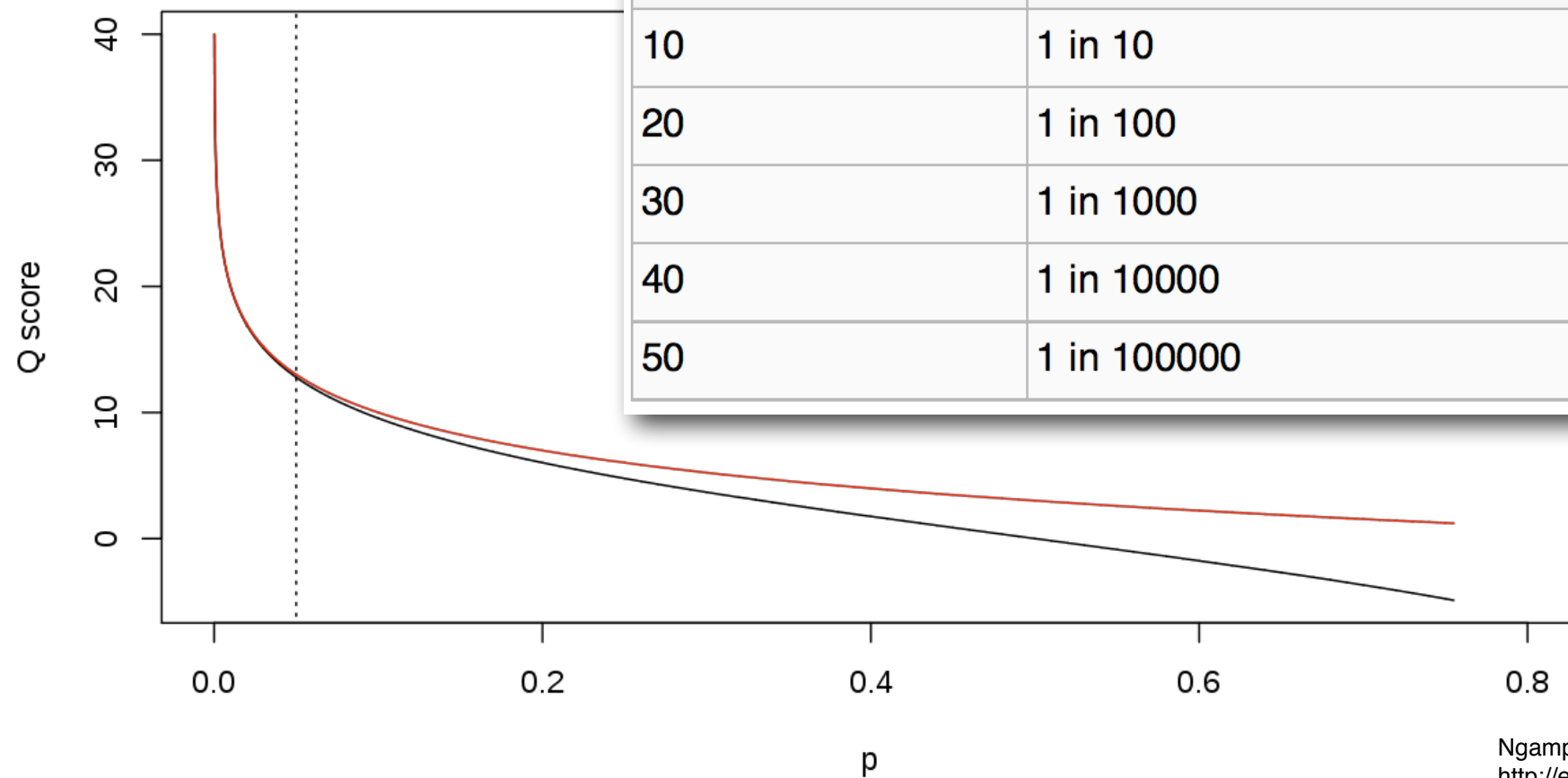
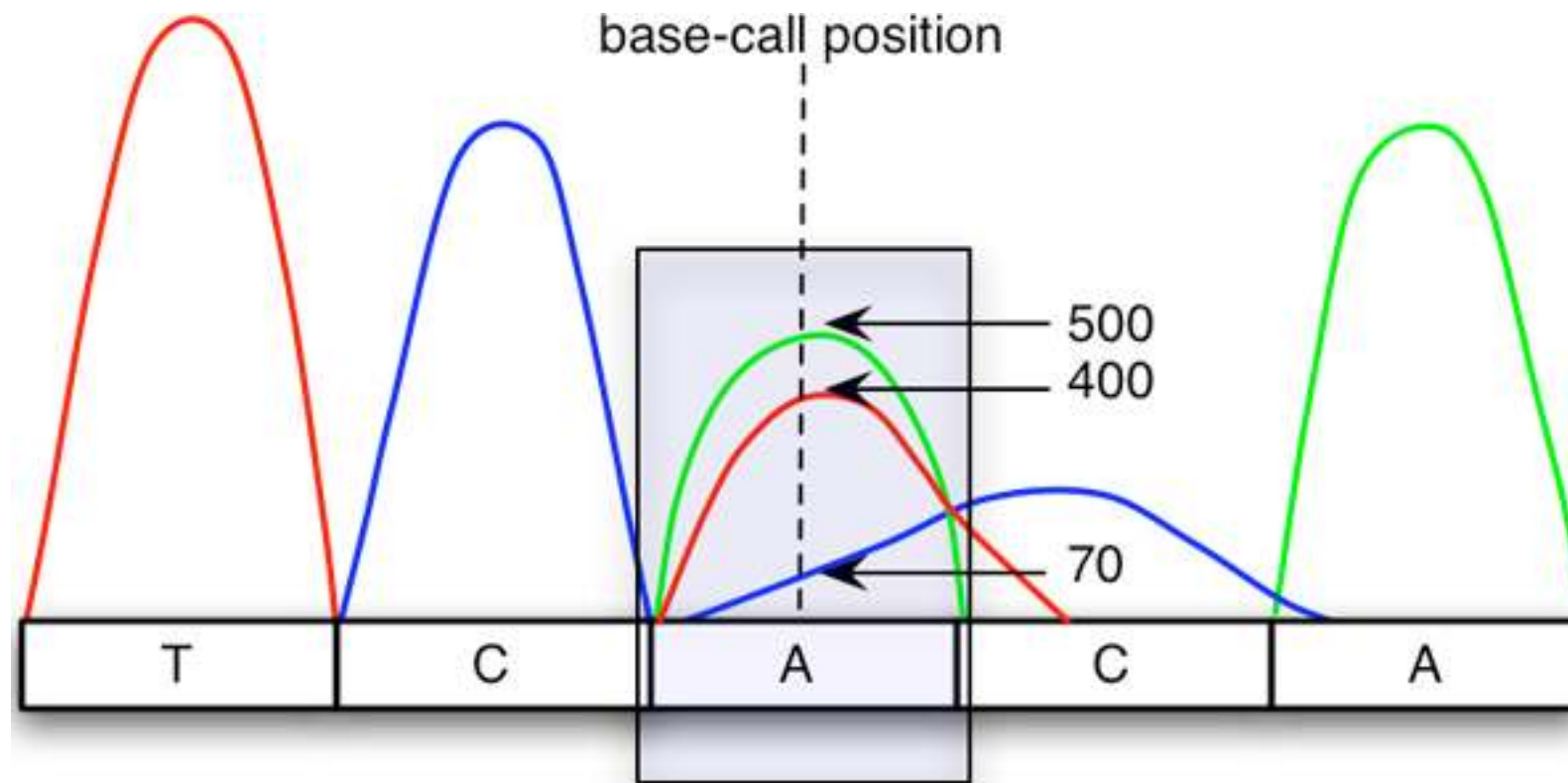
Sequencing on Illumina's Flow cell, ctd.



Phred Quality Score



Phred Quality Score



Phred Quality Score	Probability of incorrect base call	Base call accuracy
10	1 in 10	90%
20	1 in 100	99%
30	1 in 1000	99.9%
40	1 in 10000	99.99%
50	1 in 100000	99.999%

The FASTQ File Format

FASTA

```
>chromosome7  
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT  
ACATACTGCAGGGGTCAGGAGGATTATCTCCTCTGCAAGGTAACGCCTGCTGTAACCGTTGTTCTTCATCCTTTT  
CCTAACTGCAGGGGCTGTCTTGTCAGGTCTGACAAGACATATGCAGGGGCTCAATTTGAGATAATTGCTCAATATA
```

FASTQ

```
@Sequence_137  
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT  
+Sequence_137  
<?@DDDDDDHFHHFBB@GGIACFHGGHGBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66 ( 6>@C>5@CACCA
```

The FASTQ File Format

FASTA

```
>chromosome7
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT
ACATACTGCAGGGGTCAGGAGGATTATCTCCTCTGCAAGGTAACGCCTGCTGTAACCGTTGTTCTTCATCCTTTT
CCTAACTGCAGGGGCTGTCTTGTCAGGTCTGACAAGACATATGCAGGGGCTCAATTTGAGATAATTGCTCAATATA
```

FASTQ

```
@Sequence_137
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT
+Sequence_137
<?@DDDDDDHFHHFBB@GGIACFHGGHGBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66(6>@C>5@CACCA
```

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT
+
<?@DDDDDDHFHHFBB@GGIACFHGGHGBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66(6>@C>5@CACCA
```


ASCII Code

0	<NUL>	32	<SPC>	64	@	96	`	128	Ä	160	†	192	¿	224	‡
1	<SOH>	33	!	65	A	97	a	129	Å	161	°	193	ì	225	·
2	<STX>	34	"	66	B	98	b	130	Ç	162	¢	194	í	226	,
3	<ETX>	35	#	67	C	99	c	131	É	163	£	195	√	227	„
4	<EOT>	36	\$	68	D	100	d	132	Ñ	164	§	196	ƒ	228	‰
5	<ENQ>	37	%	69	E	101	e	133	Ö	165	•	197	≈	229	Â
6	<ACK>	38	&	70	F	102	f	134	Ü	166	¶	198	Δ	230	Ê
7	<BEL>	39	'	71	G	103	g	135	á	167	β	199	«	231	Á
8	<BS>	40	(	72	H	104	h	136	à	168	®	200	»	232	Ë
9	<TAB>	41	)	73	I	105	i	137	â	169	©	201	...	233	È
10	<LF>	42	*	74	J	106	j	138	ä	170	™	202		234	Í
11	<VT>	43	+	75	K	107	k	139	ã	171	'	203	À	235	Î
12	<FF>	44	,	76	L	108	l	140	å	172	“	204	Ã	236	Ï
13	<CR>	45	-	77	M	109	m	141	ç	173	≠	205	Ö	237	Ì
14	<SO>	46	.	78	N	110	n	142	é	174	Æ	206	Œ	238	Ó
15	<SI>	47	/	79	O	111	o	143	è	175	Ø	207	œ	239	Ô
16	<DLE>	48	0	80	P	112	p	144	ê	176	∞	208	-	240	Ⓜ
17	<DC1>	49	1	81	Q	113	q	145	ë	177	±	209	—	241	Ò
18	<DC2>	50	2	82	R	114	r	146	í	178	≤	210	“	242	Ú
19	<DC3>	51	3	83	S	115	s	147	ì	179	≥	211	”	243	Û
20	<DC4>	52	4	84	T	116	t	148	î	180	¥	212	`	244	Ü
21	<NAK>	53	5	85	U	117	u	149	ï	181	μ	213	'	245	ı
22	<SYN>	54	6	86	V	118	v	150	ñ	182	ð	214	÷	246	ˆ
23	<ETB>	55	7	87	W	119	w	151	ó	183	Σ	215	◇	247	˜
24	<CAN>	56	8	88	X	120	x	152	ò	184	Π	216	ÿ	248	—
25		57	9	89	Y	121	y	153	ô	185	π	217	Ÿ	249	˘
26	<SUB>	58	:	90	Z	122	z	154	ö	186	ƒ	218	/	250	·
27	<ESC>	59	;	91	[	123	{	155	õ	187	ª	219	€	251	°
28	<FS>	60	<	92	\	124		156	ú	188	º	220	<	252	¸
29	<GS>	61	=	93	]	125	}	157	ù	189	Ω	221	>	253	”
30	<RS>	62	>	94	^	126	~	158	û	190	æ	222	fi	254	˚
31	<US>	63	?	95	_	127		159	ü	191	ø	223	fl	255	˛

8 bits = 2^8 combinations = 256

0	1	1	1	1	0	0	1
---	---	---	---	---	---	---	---

$$0 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 121 = y$$

$$1 \times 10^2 + 2 \times 10^1 + 1 \times 10^0 = 121 = y$$

The FASTQ File Format, ctd

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:
TTTGTCTGCAGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT
+
<?@DDDDDFHHFBB@GGIACFHGGHBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66(6>@C>5@CACCA
```

Quality Scores

```
SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS.....  
.....XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.....  
.....IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII.....  
.....JJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJJ.....  
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL.....  
!"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_`abcdefghijklmnopqrstuvwxyz{|}~  
|          |          |          |          |  
33         59        64         73         104         126
```

S - Sanger Phred+33, raw reads typically (0, 40)
X - Solexa Solexa+64, raw reads typically (-5, 40)
I - Illumina 1.3+ Phred+64, raw reads typically (0, 40)
J - Illumina 1.5+ Phred+64, raw reads typically (3, 40)
with 0=unused, 1=unused, 2=Read Segment Quality Control Indicator (bold)
(Note: See discussion above).
L - Illumina 1.8+ Phred+33, raw reads typically (0, 41)

ASCII values 33 - 73 = 0 - 40

The FASTQ File Format, ctd

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:
TTTGTCTGCAGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT
+
<?@DDDDDFHHFBB@GGIACFHGGHBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66(6>@C>5@CACCA
```

Quality Scores

[illegible]

S - Sanger Phred+33, raw reads typically (0, 40)
X - Solexa Solexa+64, raw reads typically (-5, 40)
I - Illumina 1.3+ Phred+64, raw reads typically (0, 40)
J - Illumina 1.5+ Phred+64, raw reads typically (3, 40)
with 0=unused, 1=unused, 2=Read Segment Quality Control Indicator (bold)
(Note: See discussion above).
L - Illumina 1.8+ Phred+33, raw reads typically (0, 41)

ASCII values 33 - 73 = 0 - 40

‘F’ = 70

The FASTQ File Format, ctd

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT
+
<?@DDDDDDHFHHFBB@GGIACFHGGHBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66(6>@C>5@CACCA
```

Quality Scores

[illegible]

S - Sanger Phred+33, raw reads typically (0, 40)
X - Solexa Solexa+64, raw reads typically (-5, 40)
I - Illumina 1.3+ Phred+64, raw reads typically (0, 40)
J - Illumina 1.5+ Phred+64, raw reads typically (3, 40)
with 0=unused, 1=unused, 2=Read Segment Quality Control Indicator (bold)
(Note: See discussion above).
L - Illumina 1.8+ Phred+33, raw reads typically (0, 41)

ASCII values 33 - 73 = 0 - 40

‘F’ = 70

$$70 - 33 = 37$$

The FASTQ File Format, ctd

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:  
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT  
+  
<?@DDDDDDHFHHFBB@GGIACFHGGHGBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66 ( 6>@C>5@CACCA
```


The FASTQ File Format, ctd

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:  
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT  
+  
<?@DDDDDDHFHHFBB@GGIACFHGGHGBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66 ( 6>@C>5@CACCA
```

$$70 - 33 = 37$$

The FASTQ File Format, ctd

```
@HWI-ST0747:162:C03AJACXX:3:1108:19763:106771 1:N:0:  
TTTGTCTGCAGGGGGACACGTCAAAGTCAAACGCAGGCAAGTTTGTGTTTATGTCCAGTGGATCTTTTGATTTT  
+  
<?@DDDDDDHFHHFBB@GGIACFHGGHGBGHGCDHBEAHACHI=@CH.=7ACAHHADECDBCC66 ( 6>@C>5@CACCA
```

$$70 - 33 = 37$$

Phred Quality Score	Probability of incorrect base call	Base call accuracy
10	1 in 10	90%
20	1 in 100	99%
30	1 in 1000	99.9%
40	1 in 10000	99.99%
50	1 in 100000	99.999%

Count raw reads:

```
wc -l s_1_sequence.txt
```

```
grep "@" s_1_sequence.txt  
grep -c "@" s_1_sequence.txt
```

```
grep -v "@" s_1_sequence.txt  
grep -v -c "@" s_1_sequence.txt
```

Count reads with barcode:

```
grep -c "^CGATA" s_1_sequence.txt
```

Special Files

STDIN, STDOUT, STDERR

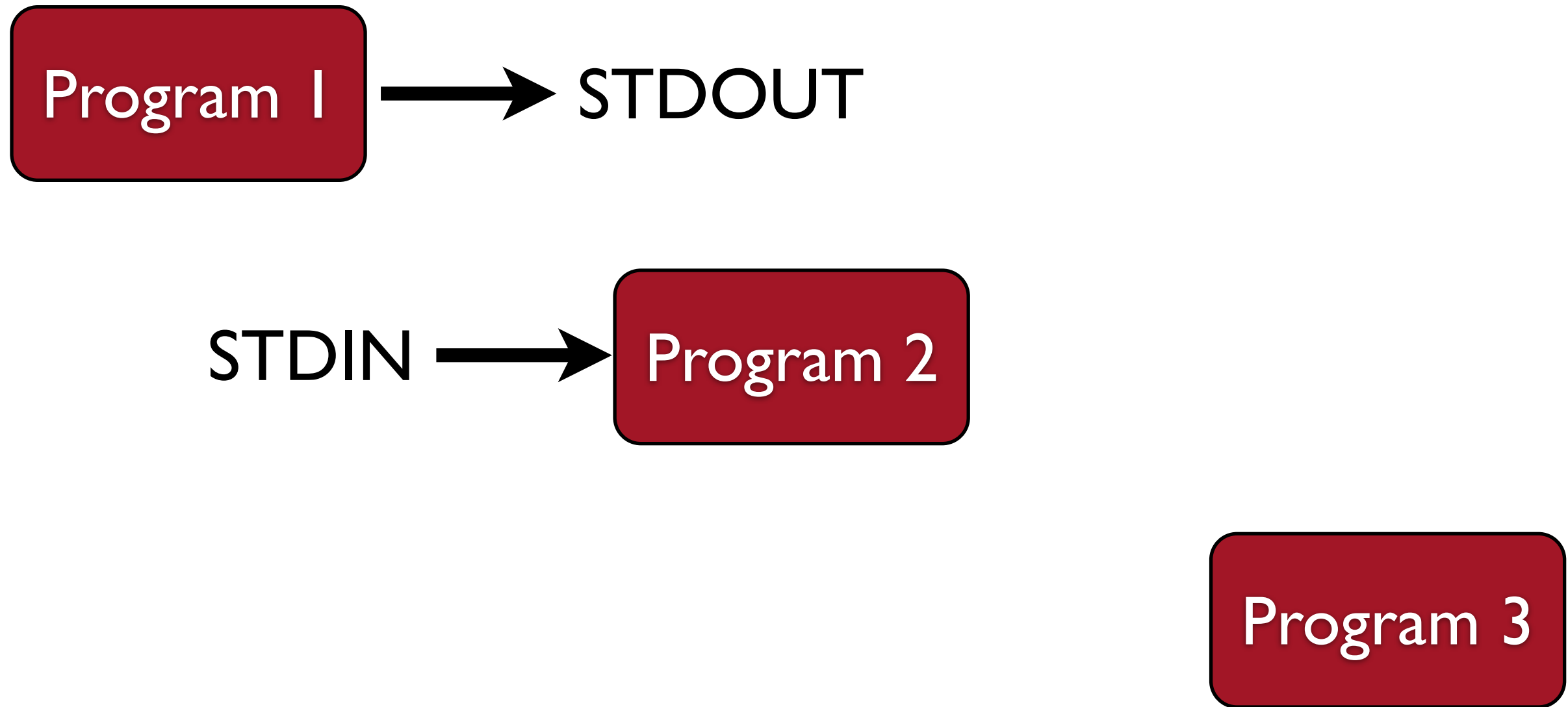
The Shell's Killer App: Pipes



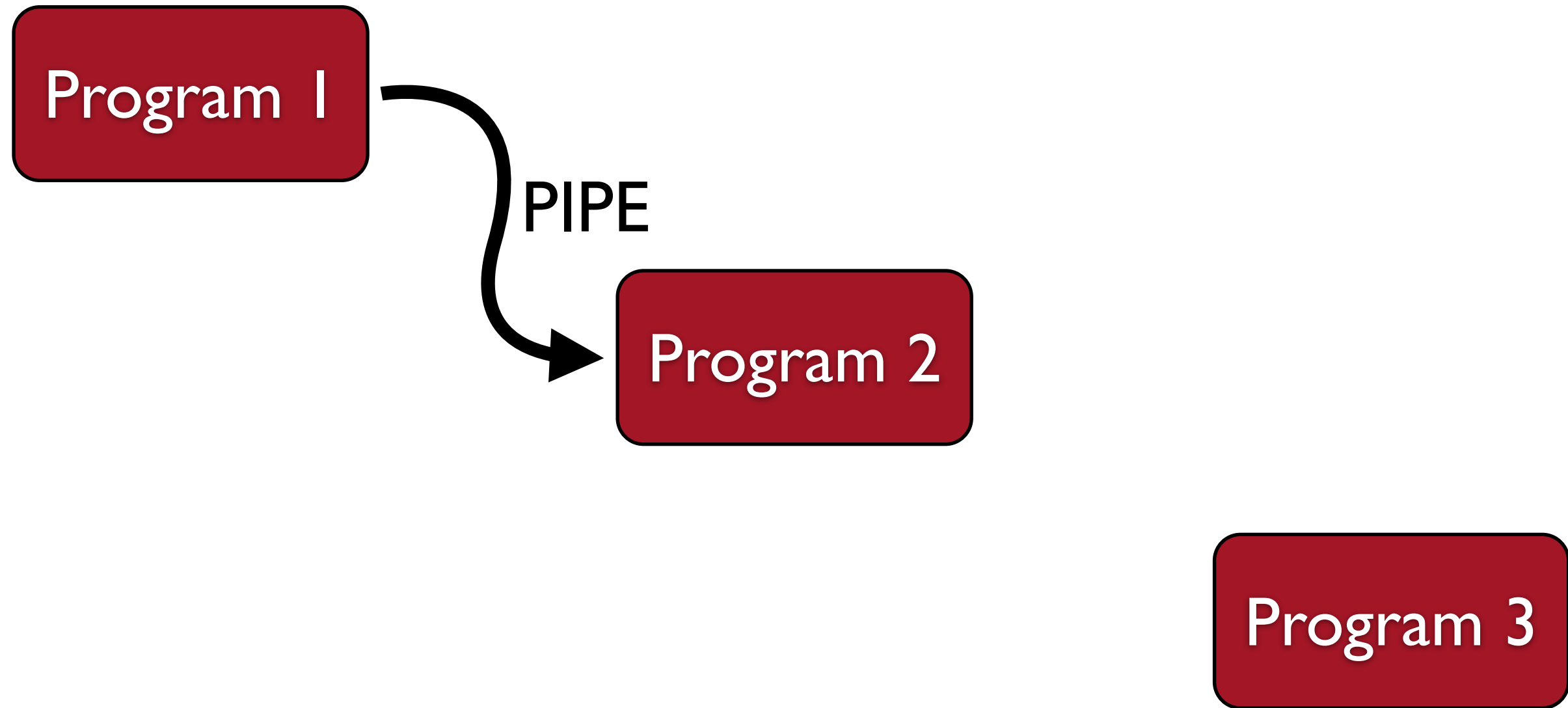
The Shell's Killer App: Pipes, ctd.



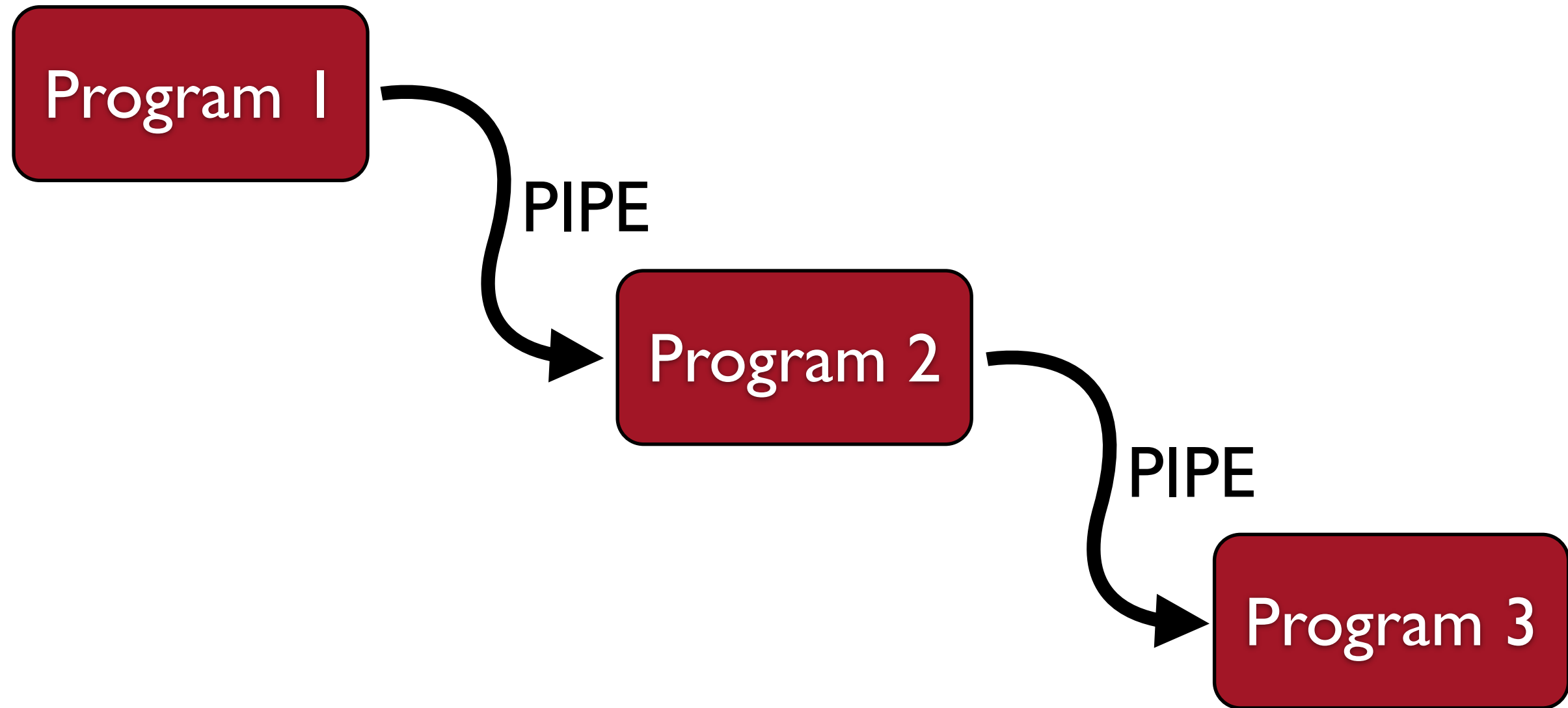
The Shell's Killer App: Pipes, ctd.



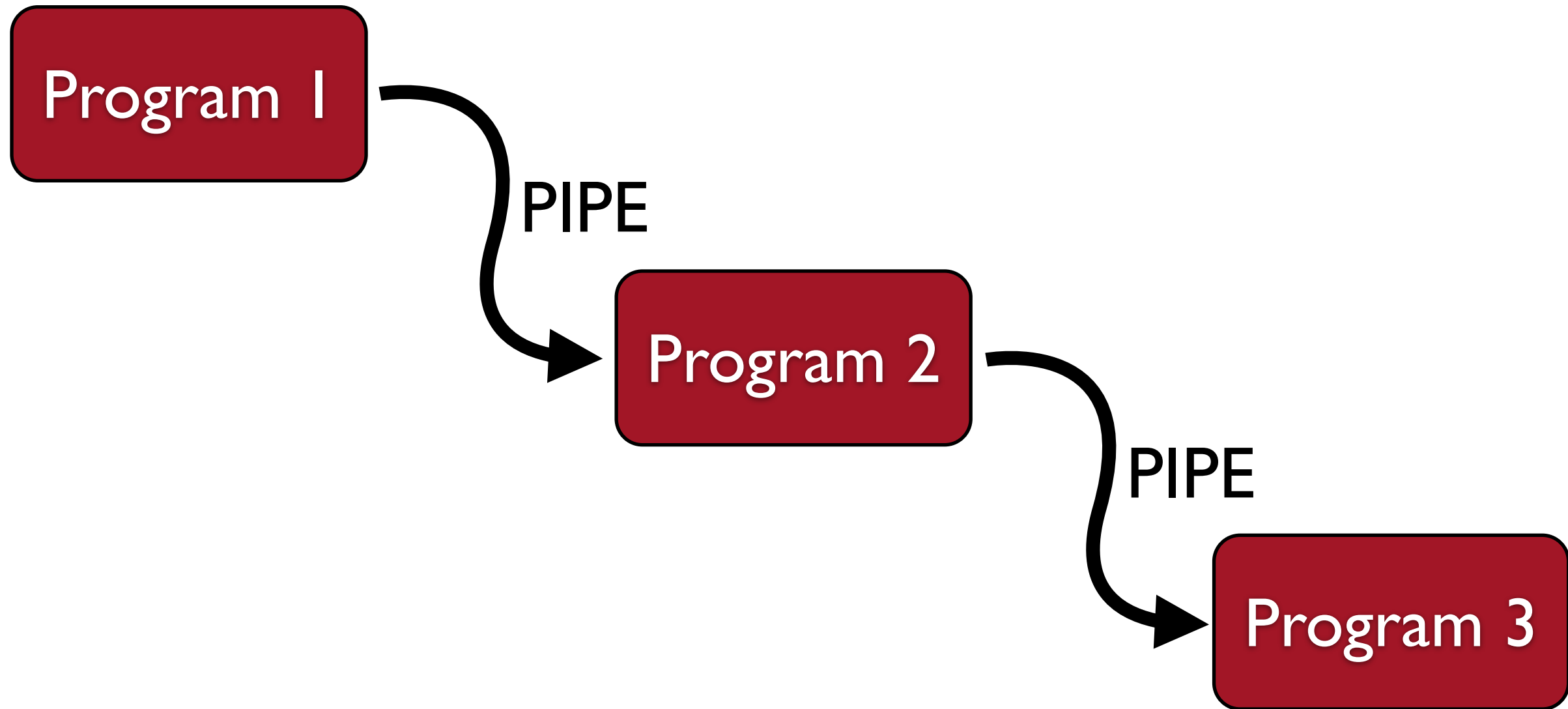
The Shell's Killer App: Pipes, ctd.



The Shell's Killer App: Pipes, ctd.



The Shell's Killer App: Pipes, ctd.



So what is the purpose of the
program **cat**?

cut

```
cut -f 10 batch_1.genotypes_1.loc
```

cut, capture the output

```
cut -f 1-10 batch_1.genotypes_1.loc > genos
```

cut, pipe the output to grep

```
cut -f 2 batch_1.genotypes_1.loc | grep -c "nnxnp"
```

```
cut -f 1-10,15,17 batch_1.genotypes_1.loc | grep "nnxnp" > genos2
```

Examine a marker, translating the output

```
cat batch_1.genotypes_1.loc | tr " " ", " | grep "^96053"
```


s_l_sequence.txt.gz

Decompress the file

1. Count the number of raw reads (250,000)
2. Count the number of reads with barcode CGATA (19,501)
3. Capture all FASTQ records for ACCAT into a file called sample_01.fq (you should get 18352 records, 73408 lines)
4. Determine the count of all barcodes in the file

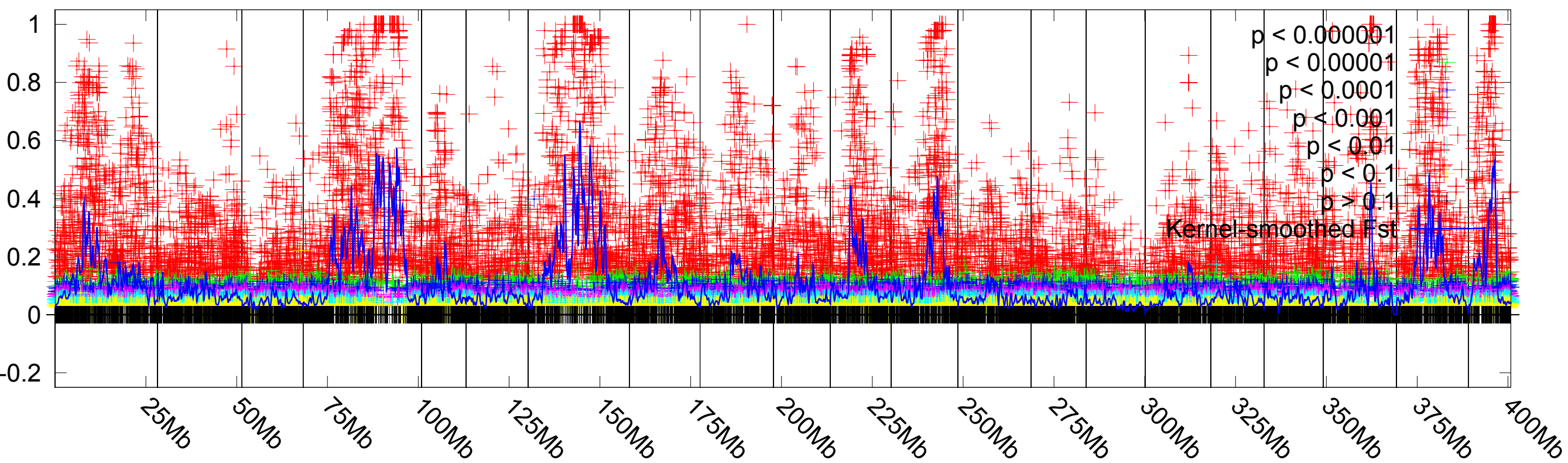
```
286 CTAGT
7900 TCAGA
10659 ACTGC
10931 TGACC
11536 GAGAT
11871 CTGAA
14409 CGGCG
14508 TGGTT
18226 GAAGC
18352 ACCAT
18375 TCGAG
19501 CGATA
23012 AATTT
26336 GCATT
31136 CTAGG
```

1. Use **head** when building a command, **cat** once the command is working
2. Look at the **-n** option for the **head** command, the **-l** option for **wc**
3. The “^” character means “must occur at beginning of line” in a **grep** search
4. Look at the **grep** options: **-c**, **-v**, **-A**, **-B**
5. Read the man pages for **sort** and **uniq** to learn how to combine them

```
ls
gunzip
man
more
cat
wc
head
cut
grep
sort
uniq
>
|
```

Problem Set #1

Danger Is. #04 vs Middleton Is. #16 Fst



#	Batch	ID	Locus	ID	Pop 1	ID	Pop 2	ID	Chr	BP	Column	Overall	Pi	Fst	Fisher's	P	Odds	Ratio
2	7894	2	3	groupI	11832	19	0.428182	-0.0076252913						0.191294			0.687192	
2	7896	2	3	groupI	11900	83	0.328622	0.1775694587						4.35747e-08			5.44667	
2	9611	2	3	groupI	49756	48	0.090426	-0.1127451906						0.00109115			0.0898072	
2	9611	2	3	groupI	49765	57	0.0132887	-0.1522407447						0.518395			0.493113	
2	9611	2	3	groupI	49766	58	0.0133776	-0.1563725438						0.520033			0.501401	
...																		
2	7083	2	3	groupIX	20172984	57	0.0480227	-0.1249752728						0.0230205			0.152263	
2	7083	2	3	groupIX	20173004	77	0.0181808	-0.1405892833						0.27288			0.355556	
2	7083	2	3	groupIX	20173016	89	0.0424072	-0.1243625038						0.0442229			0.17037	
2	7083	2	3	groupIX	20173018	91	0.148072	0.2305903127						2.24832e-07			13.2936	
2	7084	2	3	groupIX	20172960	29	0.388239	-0.0102170169						0.307185			0.758001	
2	7084	2	3	groupIX	20172995	64	0.368259	-0.0130602425						0.233889			0.70084	
2	7084	2	3	groupIX	20173013	82	0.0121578	-0.1359057575						0.51309			0.46472	