Unix Workshop

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OCIO/ORIS

Outline

1. Unix- what and why
2. Understanding the file systems
3. Basic commands for working with files
4. grep
5. Pipes and redirection
6. Compressing files

If you know the basics of this content, pull up the man page and dig deeper.

Unix

Unix

- A family of operating systems
- Created in the 1970s
- Multi-user, multi-task
- Very flexible: scriptable, extensible
- Linux+MacOS+Solaris+… = most of the computing world

Why learn Unix

- Long lived- tools learned here will be applicable for your career
- Just about every major technology is built around Unix (especially Linux)

Linux

- Developed in early 90s
- All open source- before there were licenses and fees

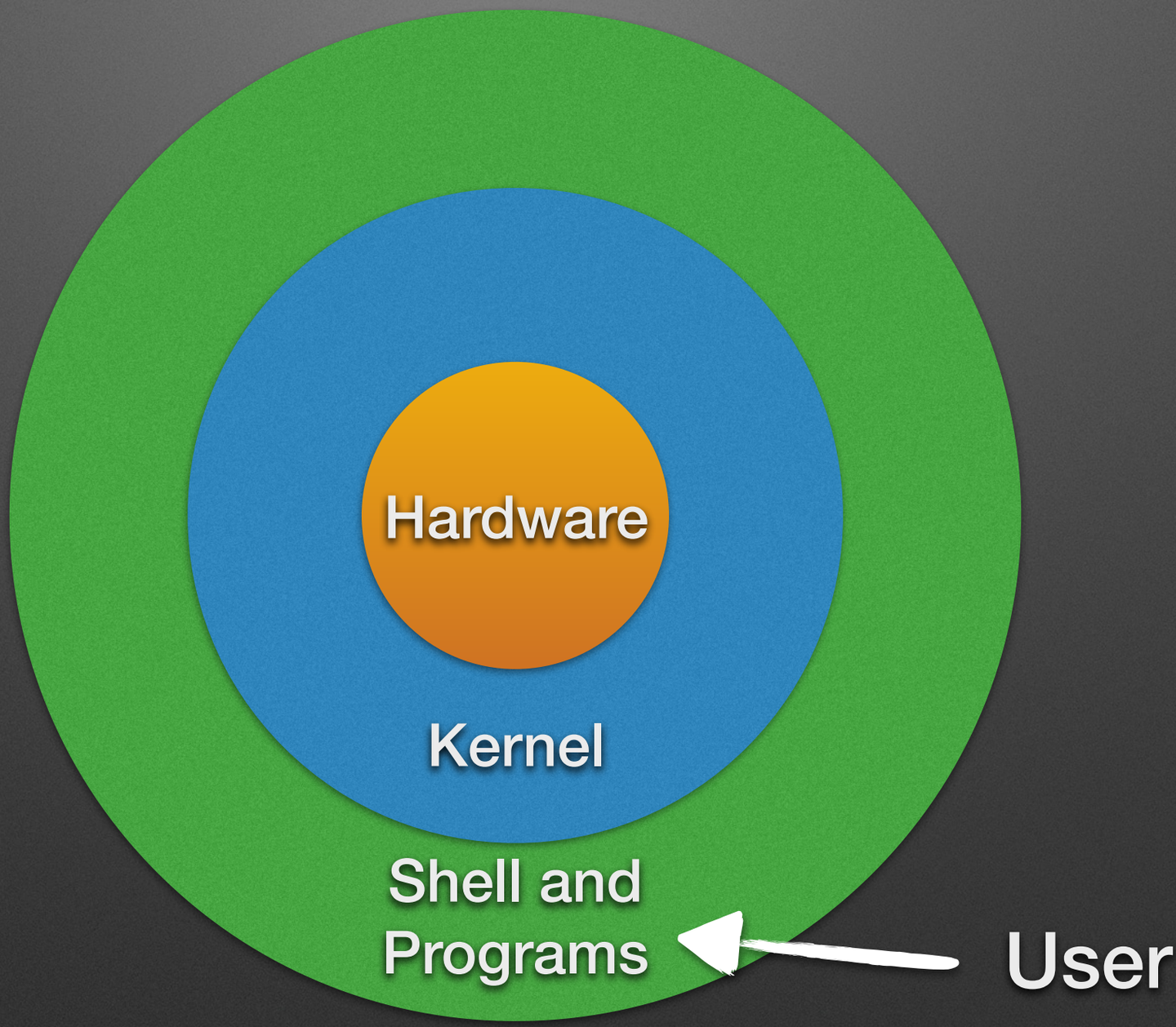
Kernel (communicates with hardware)
developed by Linus Torvalds

+

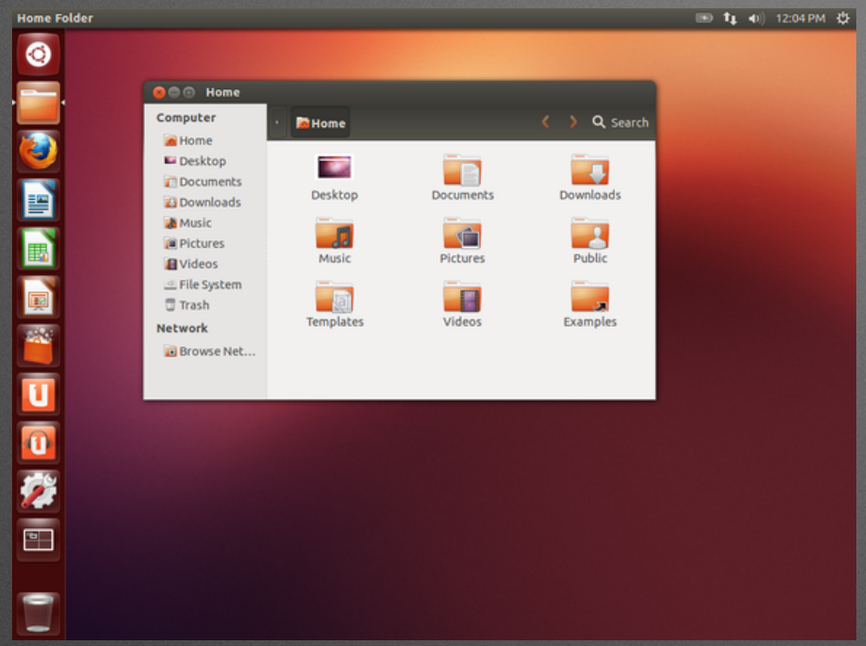
Shell and core programs
developed by Richard Stallman
(GNU = GNU's Not Unix)

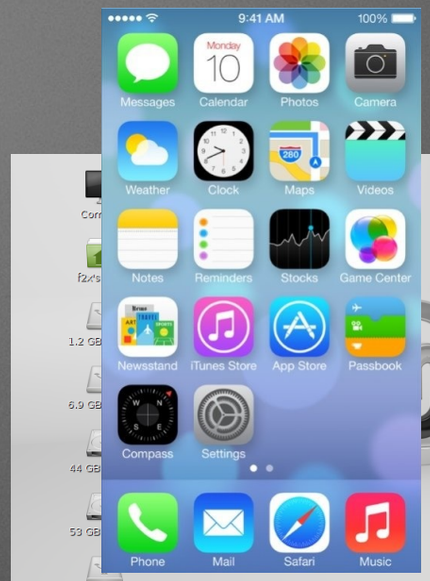
- Hundreds of versions and branches (distributions)
  - Ubuntu, Red Hat, CentOS (on Hydra), SUSE, Debian

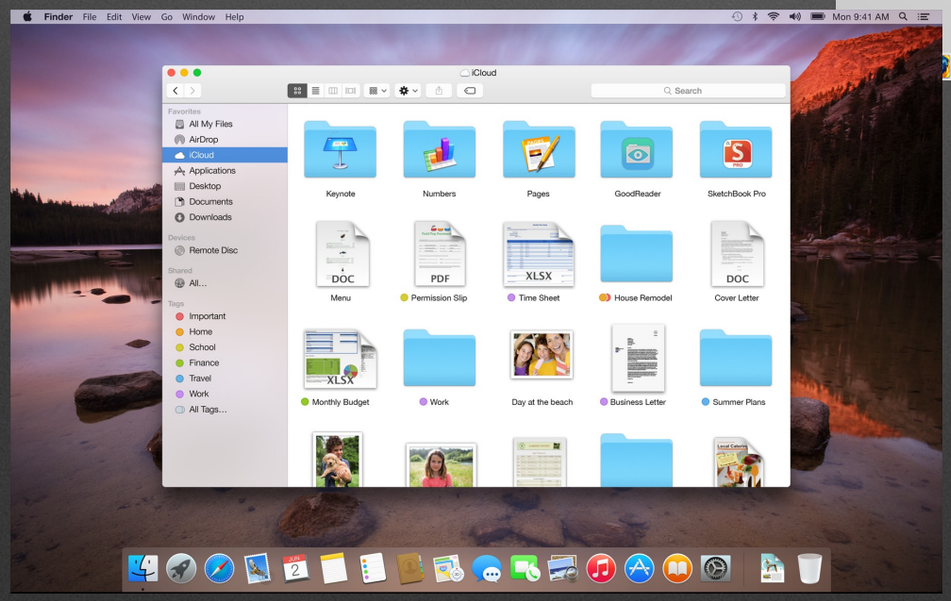
Kernel + shell/programs

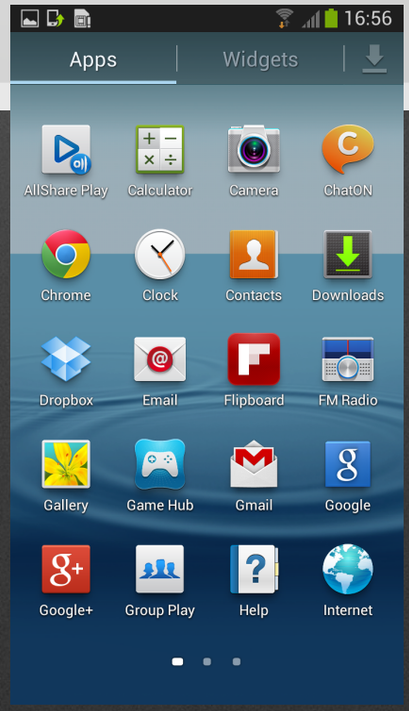


There can be a GUI









Or no GUI...


digital pdp

```
SLMIN .SYS    12P 20-Dec-85     VM    .SYS     3P 13-Aug-86
XL    .SYS     4P 20-Dec-85     LD    .SYS     8P 23-Aug-86
SP    .SYS     6P 13-Aug-86     BL    .SYS     5P 13-Aug-86
RT11SJ.SYS    78P 13-Aug-86     DU    .SYS     8P 13-Aug-86
NL    .SYS     2P 13-Aug-86     TT    .SYS     2P 13-Aug-86
SQ    .SYS     5P 31-May-85     RL02DG.SYS    71P 21-Nov-84
BASIC .SAV    56  24-May-79     BINCOM.SAV    24  20-Dec-85
DATIME.SAV     4  20-Dec-85     DIR   .SAV    19  20-Dec-85
DUMP  .SAV     9  20-Dec-85     DUP   .SAV    47  20-Dec-85
TSXMOD.SAV    78  27-Nov-92     FORTRA.SAV   206  21-May-85
HARRIS.SAV    41  12-Jun-85     LET   .SAV     5  20-Dec-85
START .P36     2  21-Dec-91     RETRO .OBJ  1519P 16-May-88
EM1A  .STM    19P 02-Feb-93     TSXUCL.TSX    22  07-Mar-92
STAND .LIN    12P 15-Aug-83     TSXV6 .MSG     1P 04-Sep-95
EM1B  .STM    19  11-Feb-93     JKFLIP.SAV    30  08-Mar-96
JKFLIP.FOR     3  08-Mar-96     RT11FB.SYS    93P 20-Dec-85
ANNOT .SAV    38  18-Apr-93     TSXP23.NEW  1200P 27-Nov-92
DUO   .DIR    18  16-Jul-96     DL    .DIR     7  16-Jul-96
DIR   .DIF    26  16-Jul-96     DEMOFG.OBJ     1     -BAD-
DEMOBG.OBJ     1     -BAD-      EVAN  .ID      1
 114 Files, 5949 Blocks
 14433 Free blocks

.0
```

BC-BS 20768

digital VT100

dave@nostromo: ~

```
drwx------   6 dave dave    4096 Aug 31 22:56 .purple
drwxrwxr-x   3 dave dave    4096 May  1 20:48 .pyrenamer
drwx------   4 dave dave    4096 Apr  9 22:40 .recoll
drwx------   2 dave dave    4096 Aug 19 09:40 .remmina
-rw-rw-r--   1 dave dave      66 Apr 10 21:51 .selected_editor
drwxrwxr-x   4 dave dave    4096 Apr  9 21:11 .shotwell
drwxrwxr-x   3 dave dave    4096 Aug 17 07:36 .shutter
drwxrwxr-x   3 dave dave    4096 Jun 23 14:22 .subversion
drwxrwxr-x   6 dave dave    4096 Jun 23 15:23 SVN
drwxrwxr-x   3 dave dave    4096 Apr 29 15:13 .teamviewer
drwxr-xr-x   2 dave dave    4096 Apr  9 16:12 Templates
drwxr-xr-x   4 dave dave    4096 Aug 29 22:04 .themes
drwx------   4 dave dave    4096 Apr  9 16:28 .thumbnails
drwx------   4 dave dave    4096 Oct 22  2011 .thunderbird
drwxrwxr-x   2 dave dave    4096 Jun  1 22:24 Ubuntu One
drwx------   2 dave dave    4096 Sep  1 22:57 VBShared
drwxr-xr-x 149 dave dave    4096 Aug 24 20:57 Videos
-rw-------   1 dave dave     707 Jul 20 22:26 .viminfo
drwxrwxr-x   2 dave dave    4096 Sep  1 18:08 .VirtualBox
drwx------   5 dave dave    4096 Jul  1 17:41 VirtualBox VMs
-rw-------   1 dave dave      53 Sep  2 09:24 .Xauthority
-rw-------   1 dave dave  166801 Sep  2 17:11 .xsession-errors
-rw-------   1 dave dave 1163071 Sep  1 23:49 .xsession-errors.old
dave@nostromo:~$
```

dave@nostromo: ~

```
top - 17:13:03 up  8:04,  4 users,  load average: 0.11, 0.14, 0.22
Tasks: 172 total,   3 running, 169 sleeping,   0 stopped,   0 zombie
Cpu(s):  2.0%us,  1.8%sy,  0.0%ni, 95.8%id,  0.3%wa,  0.0%hi,  0.1%si,  0.0%st
Mem:   4122428k total,  1879668k used,  2242760k free,   253144k buffers
Swap:  4190204k total,        0k used,  4190204k free,  1062176k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
 1843 dave      20   0  291m 133m  38m S    7  3.3  14:53.01 compiz
 1246 root      20   0 71232  52m  12m R    5  1.3  14:54.29 Xorg
16709 dave      20   0  187m  47m  19m S    3  1.2   0:01.86 shutter
15911 dave      20   0  125m  19m  12m S    1  0.5   0:03.00 gnome-terminal
 2073 dave      20   0 94568 5932 4540 S    1  0.1   3:16.70 conky
 1994 dave      20   0 41816  10m 8168 S    0  0.3   0:08.98 gtk-window-deco
16395 dave      20   0  2836 1160  860 R    0  0.0   0:00.46 top
    1 root      20   0  3516 1908 1248 S    0  0.0   0:00.80 init
    2 root      20   0     0    0    0 S    0  0.0   0:00.01 kthreadd
    3 root      20   0     0    0    0 S    0  0.0   0:00.94 ksoftirqd/0
                                       0 S    0  0.0   0:00.57 kworker/u:0
                                       0 S    0  0.0   0:00.00 migration/0
    7 root      RT   0     0    0    0 S    0  0.0   0:00.22 watchdog/0
    8 root      RT   0     0    0    0 S    0  0.0   0:00.00 migration/1
   10 root      20   0     0    0    0 S    0  0.0   0:00.84 ksoftirqd/1
   12 root      RT   0     0    0    0 S    0  0.0   0:00.21 watchdog/1
   13 root      RT   0     0    0    0 S    0  0.0   0:00.00 migration/2
```

dave@nostromo: ~

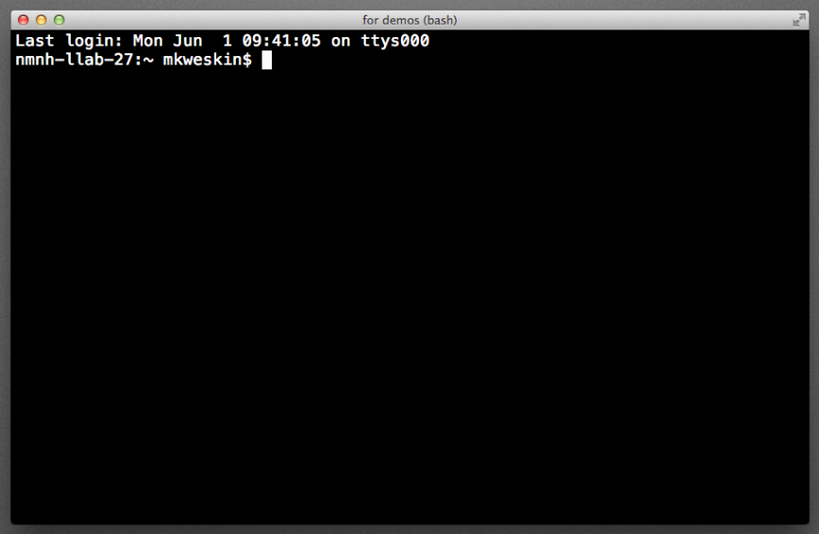
```
alias l='ls -CF'

# Add an "alert" alias for long running commands.  Use like so:
#   sleep 10; alert
alias alert='notify-send --urgency=low -i "$([ $? = 0 ] && echo terminal || echo
 error)" "$(history|tail -n1|sed -e '\''s/^\s*[0-9]\+\s*//;s/[;&|]\s*alert$//'\'
')"'

# Alias definitions.
# You may want to put all your additions into a separate file like
# ~/.bash_aliases, instead of adding them here directly.
# See /usr/share/doc/bash-doc/examples in the bash-doc package.

if [ -f ~/.bash_aliases ]; then
    . ~/.bash_aliases
fi

# enable programmable completion features (you don't need to enable
# this, if it's already enabled in /etc/bash.bashrc and /etc/profile
# sources /etc/bash.bashrc).
if [ -f /etc/bash_completion ] && ! shopt -oq posix; then
    . /etc/bash_completion
fi
dave@nostromo:~$
```

```
SYSTEM
nostromo Linux 3.2.0-29-generic-pae on i686
Uptime: 8h 4m 18s
Processes: 172  Threads: 369

CPU
AMD Athlon(tm) II X4 640 Processor x 4

Total CPU: 14%
Core 1: 800 MHz
17%
Core 2: 3000 MHz
15%
Core 3: 800 MHz
11%
Core 4: 800 MHz
14%

NAME                PID   CPU%   MEM%
compiz             1843   1.52   3.38
Xorg               1246   1.18   1.33
shutter           16709   0.59   1.22
conky              2073   0.17   0.15

MEMORY
RAM Used: 551MiB  RAM Free: 2.14GiB/ 3.93GiB
 RAM: 13%
Swap: 0%

DISK
sdc5 ext4 (Root): 61%
sdc1 NTFS (Data): 0%

TEMP
Fan:  1236 rpm
Tmp:  +30.0°C

NETWORK (192.168.4.16)
Wired Connection
IP:                          192.168.4.16
Up:                             38B  k/s
Down:                           19B  k/s
```

Why command line?

- Many bioinformatics programs can only be run from the command line
- Access
  - To computers via remote login
    - Multiple users can access at one time
- Advantages
  - Tight control on what is being done
  - Batch processing require scripts (commands)
- Shared resource
  - Not sole user of computer

Shell

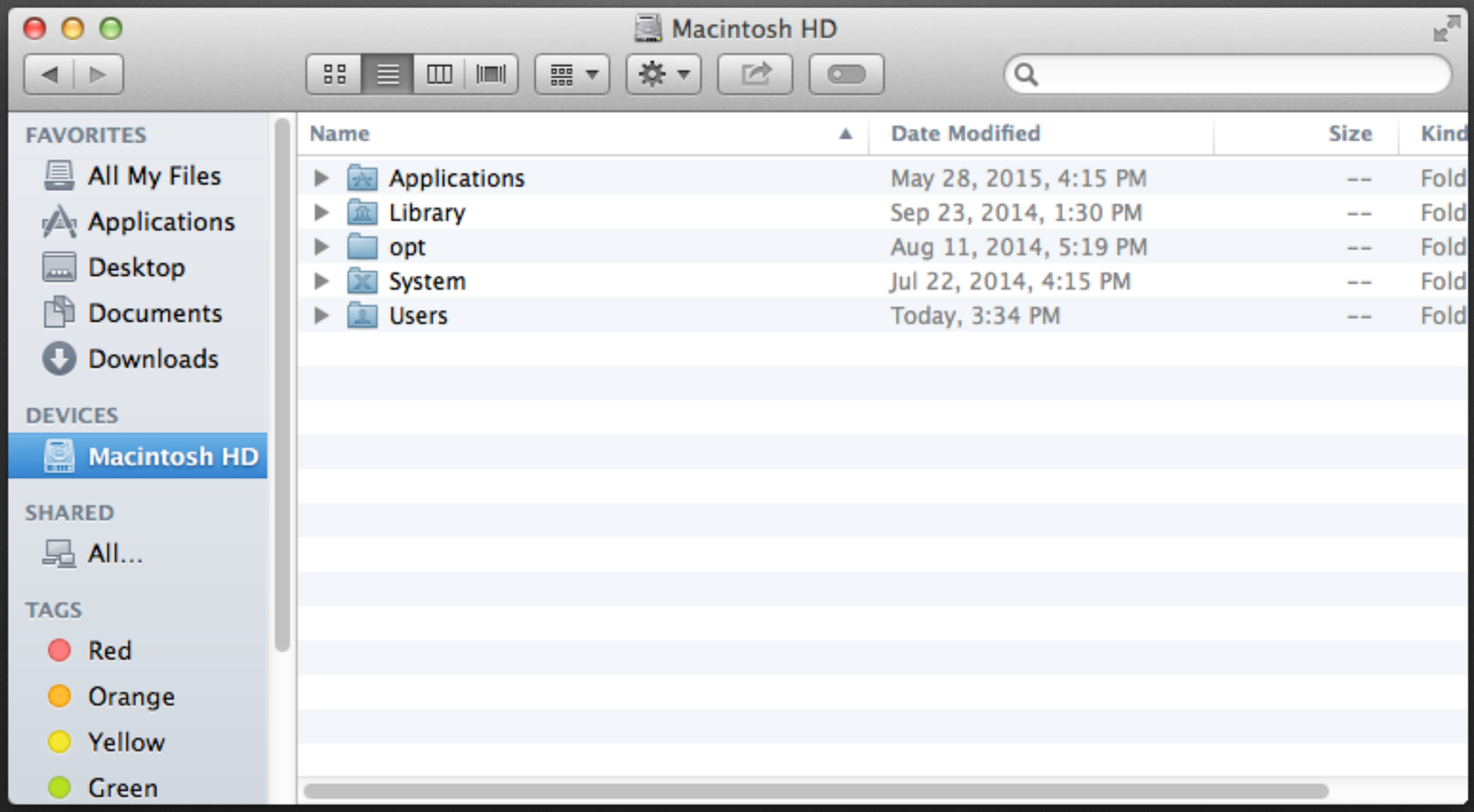


- Lingo for the program that is started when you login
- The command line interpreter- takes and executes your instructions
- Two major shells: `bash` (or `sh`) and `csh` (or `tcsh`)
  - `bash` being taught here and we're using as default for genomics users on Hydra
  - Some formatting differs between shells. You can try another shell

File structure

How things are organized on a disk

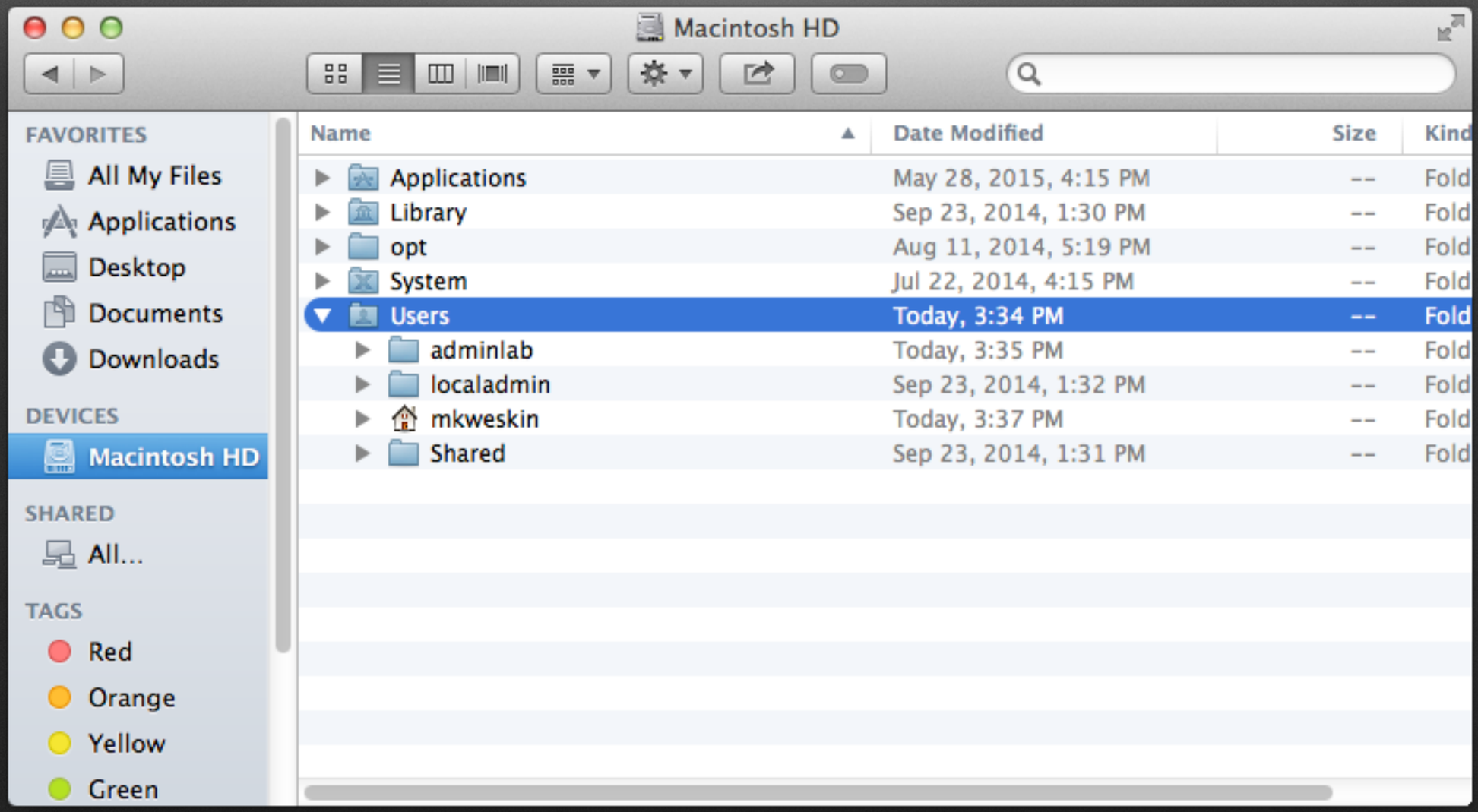
Identifying where things are
Paths



/

/ “Root”: top most directory on a system, everything is inside it

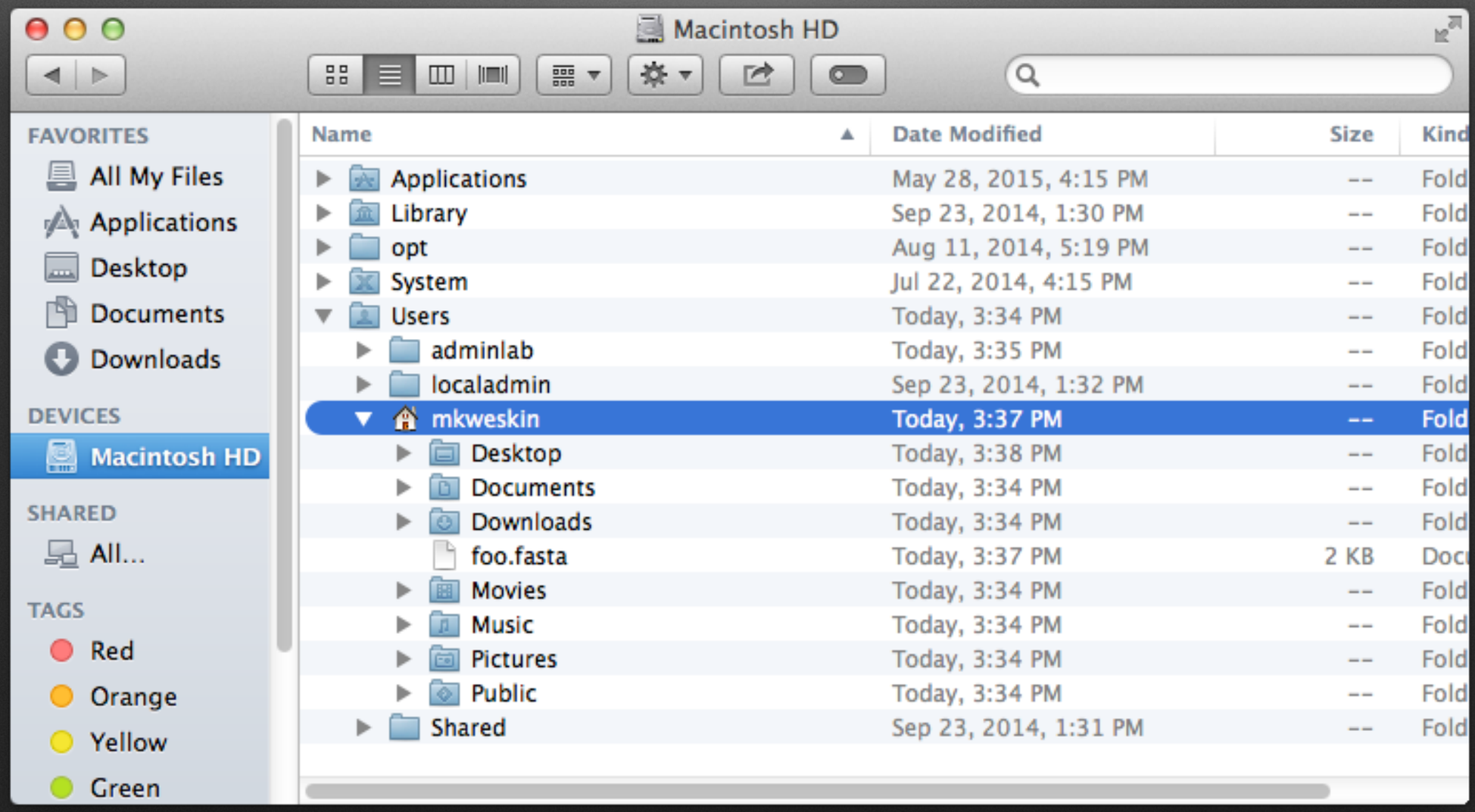
Identifying where things are Paths



`/Users/`

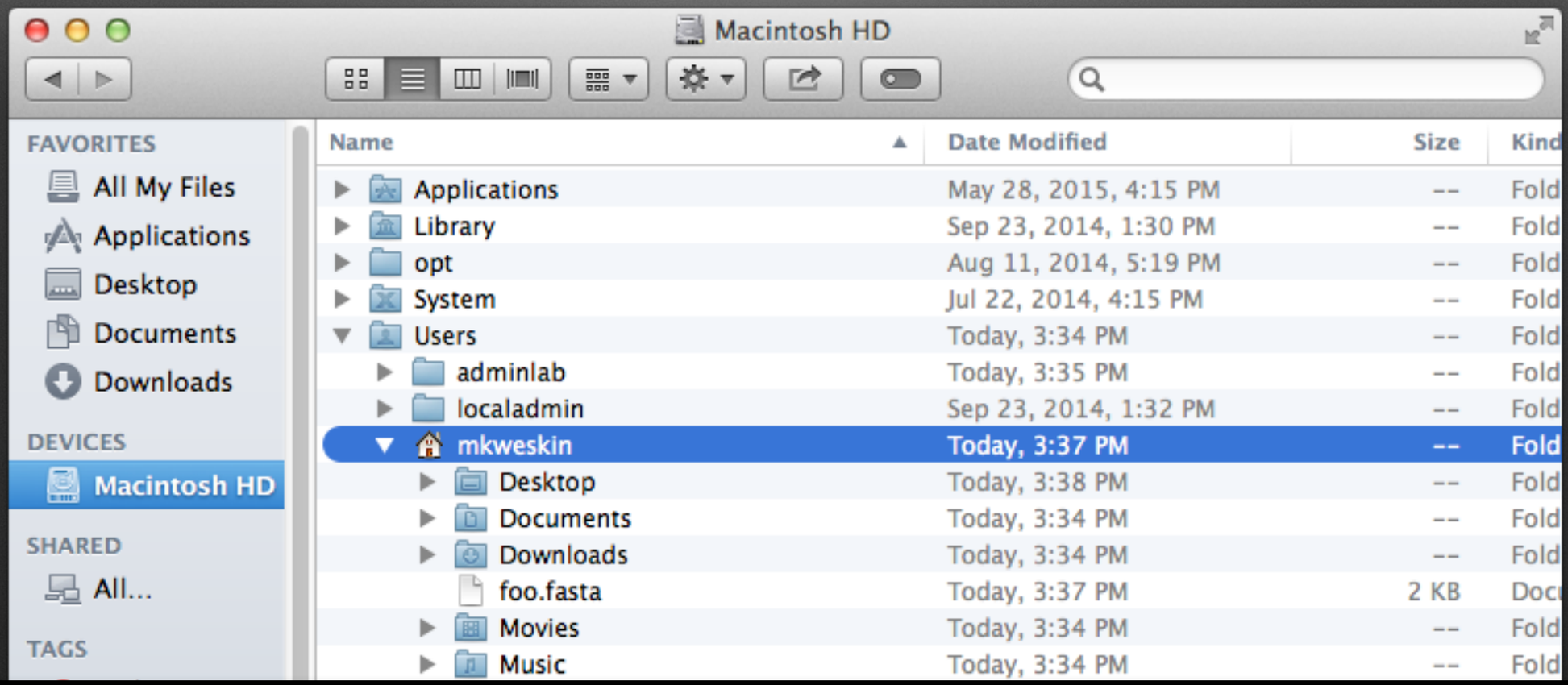
Ending / means a directory

Identifying where things are Paths



`/Users/mkweskin/`

Identifying where things are Paths

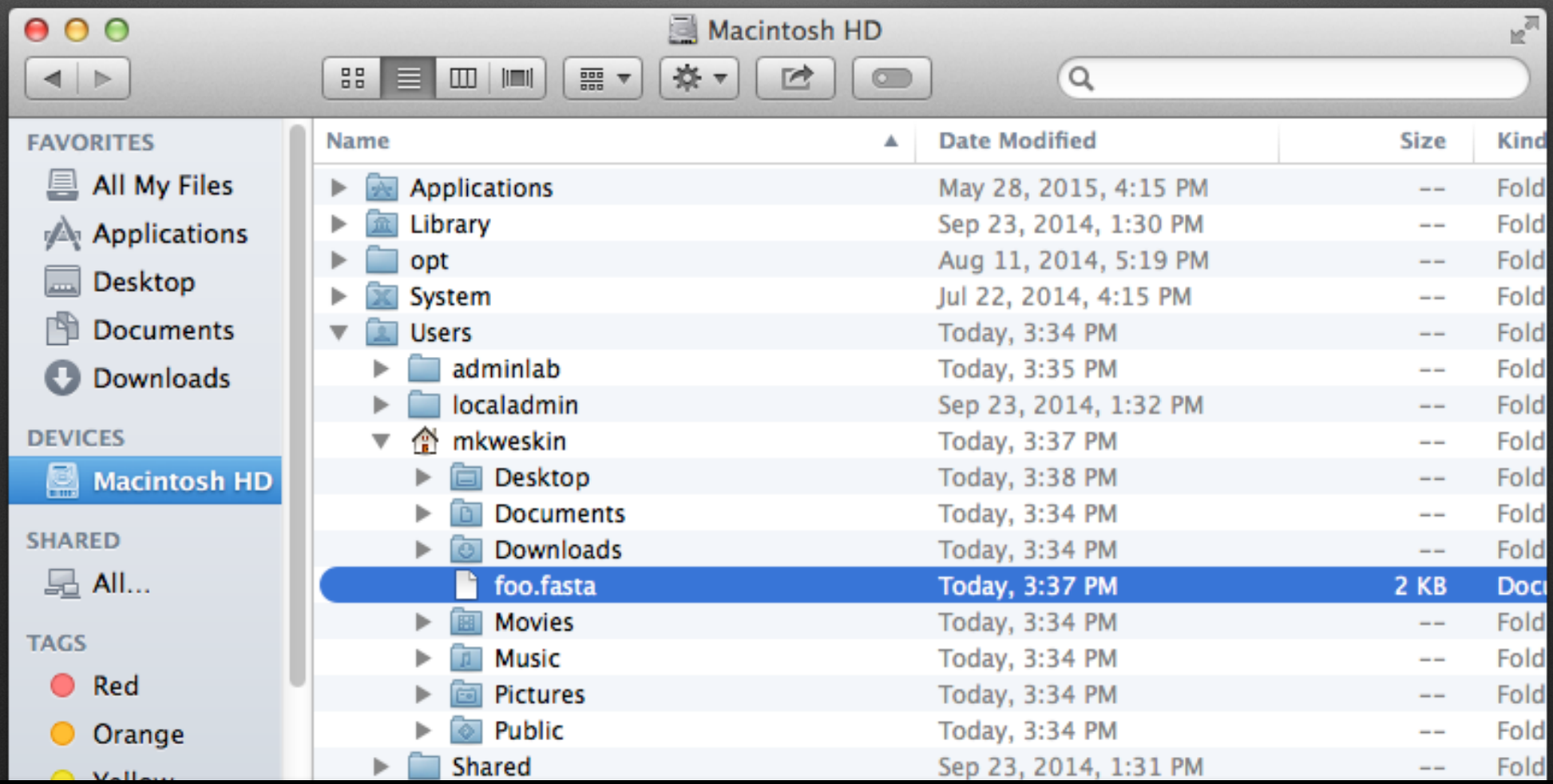


`/Users/mkweskin`

or `~`

(Mac home directory, linux is /home/user)

Identifying where things are Paths



/Users/mkweskin/foo.fasta
or ~/foo.fasta

Absolute vs relative paths

- Absolute file path: starts with a `/`
  - Complete path to the file. Works regardless of current directory.

```
/Users/mkweskin/foo.fasta
```

- Relative file path: starts with another directory or no directory
  - **Depends on current directory**

```
foo.fasta
mkweskin/foo.fasta
../localadmin/bar.fasta
```

Absolute vs relative paths

- Some analysis programs *require full paths* to input files. If the program documentation says full path, give it.

Special files/directories

- `.file` Files/directories starting with a `.` are hidden when you `ls`. Often used for config files, especially in your home directory.
- `.` Refers to the current directory
- `..` Refers to the parent directory

File/Directory Naming

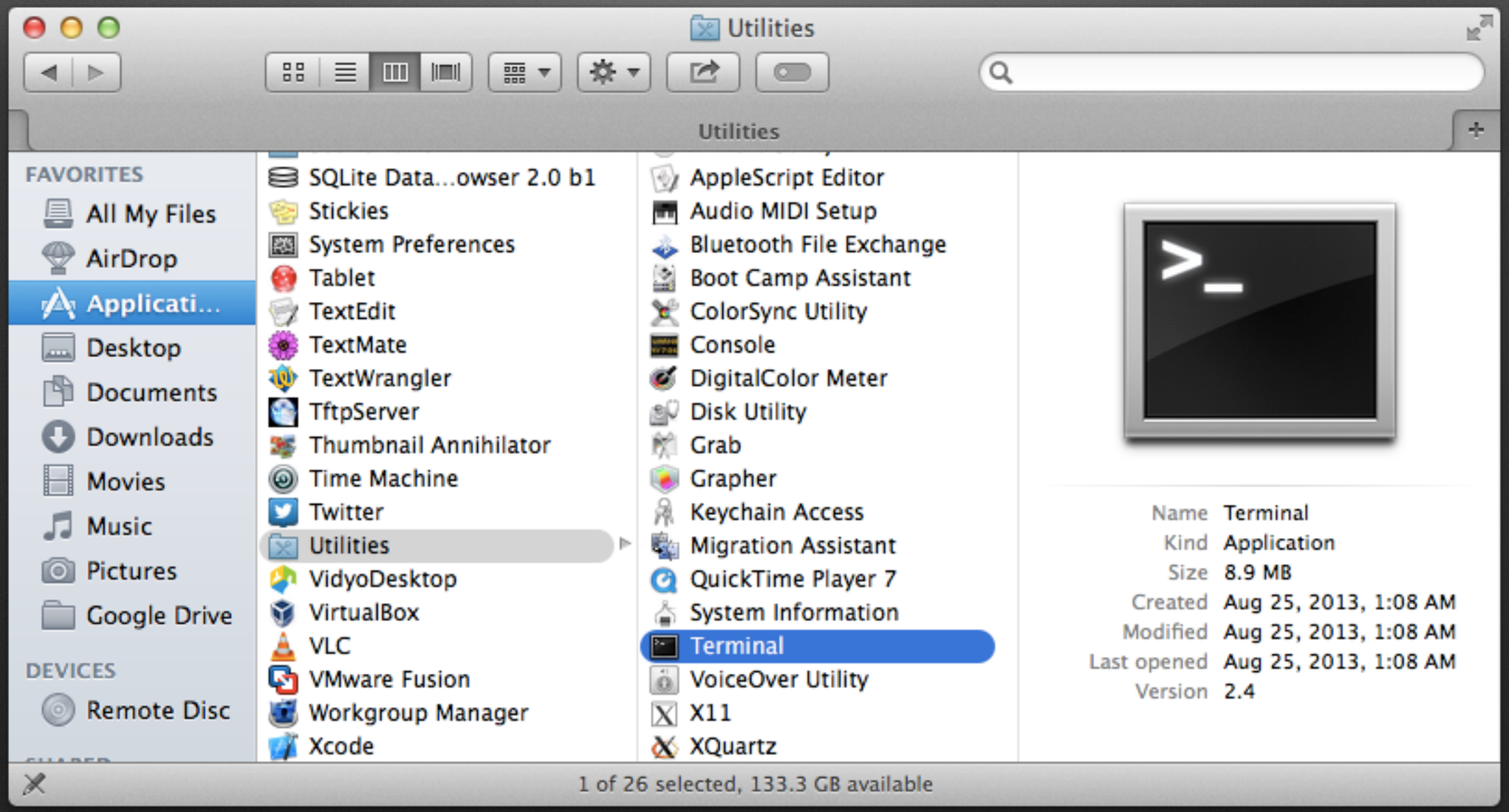
- Names are case sensitive
- There are no rules, just conventions
- Technically you can use just about weird character you want, but DON'T

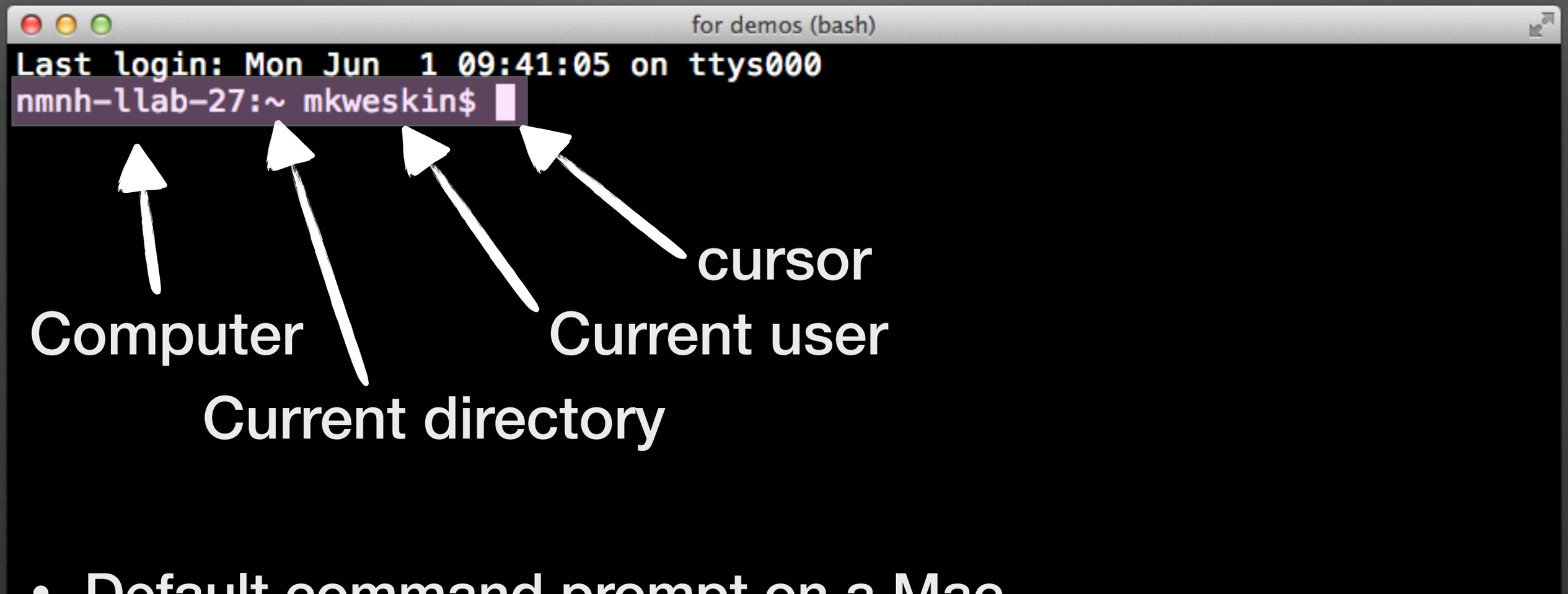
- USE:
  - Letters numbers _ - +

- AVOID:
  - `space  <  >  &  |  !  (  )  ?  *  '  "  \  $`
  - non-printable chars, emoji
  - names starting with – or ~

The command prompt…
Let’s run commands!

Starting the Terminal (Mac)





- Default command prompt on a Mac
- After the $ (sometimes % or #) is the command
  - Usually: $=`bash` %=`csh` #=running as superuser (root)
  - Don’t retype the $, %, # when following instructions

Current directory

- You’re always in a directory at the command prompt
  - Equivalent to window being show in the Mac Finder or Windows Explorer
  - Commands you run will affect files in this directory unless you specify another

Commands

```
command [options] arguments
```

```
$ ls -l ~/Downloads
```

- `command`: name of the command
- `options` (or flags or switches): additional program options
  - `-x` or `--name` (often: one hyphen for single letter, two for longer)
  - `[ ]` means optional
  - When sure it's a "regular" hyphen not — or –

- `arguments` (or parameter): file or data for program to use

Getting help

- `man` Manual page, reference instructions

```
$ man command
```

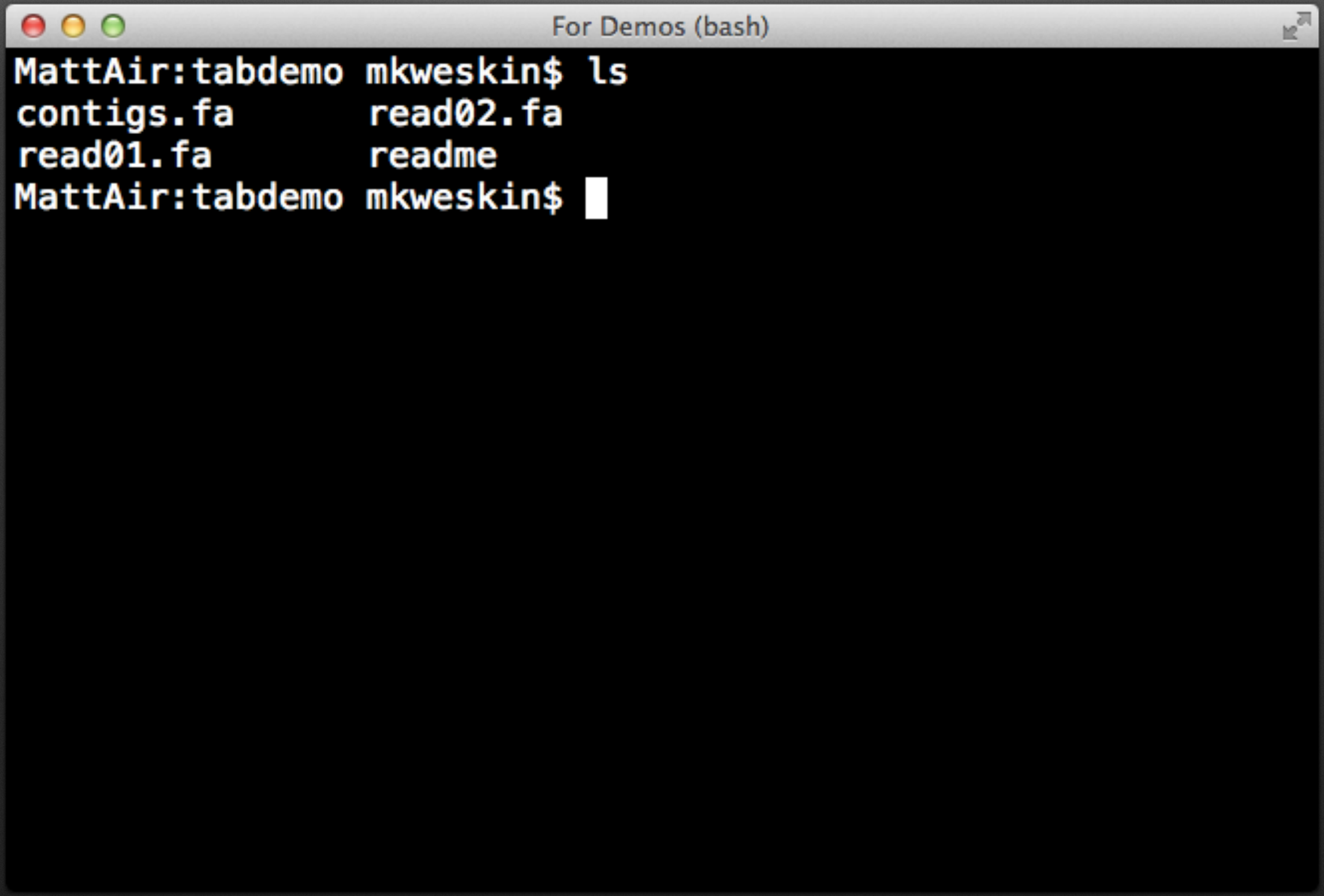
- Brief usage screen (varies by command)

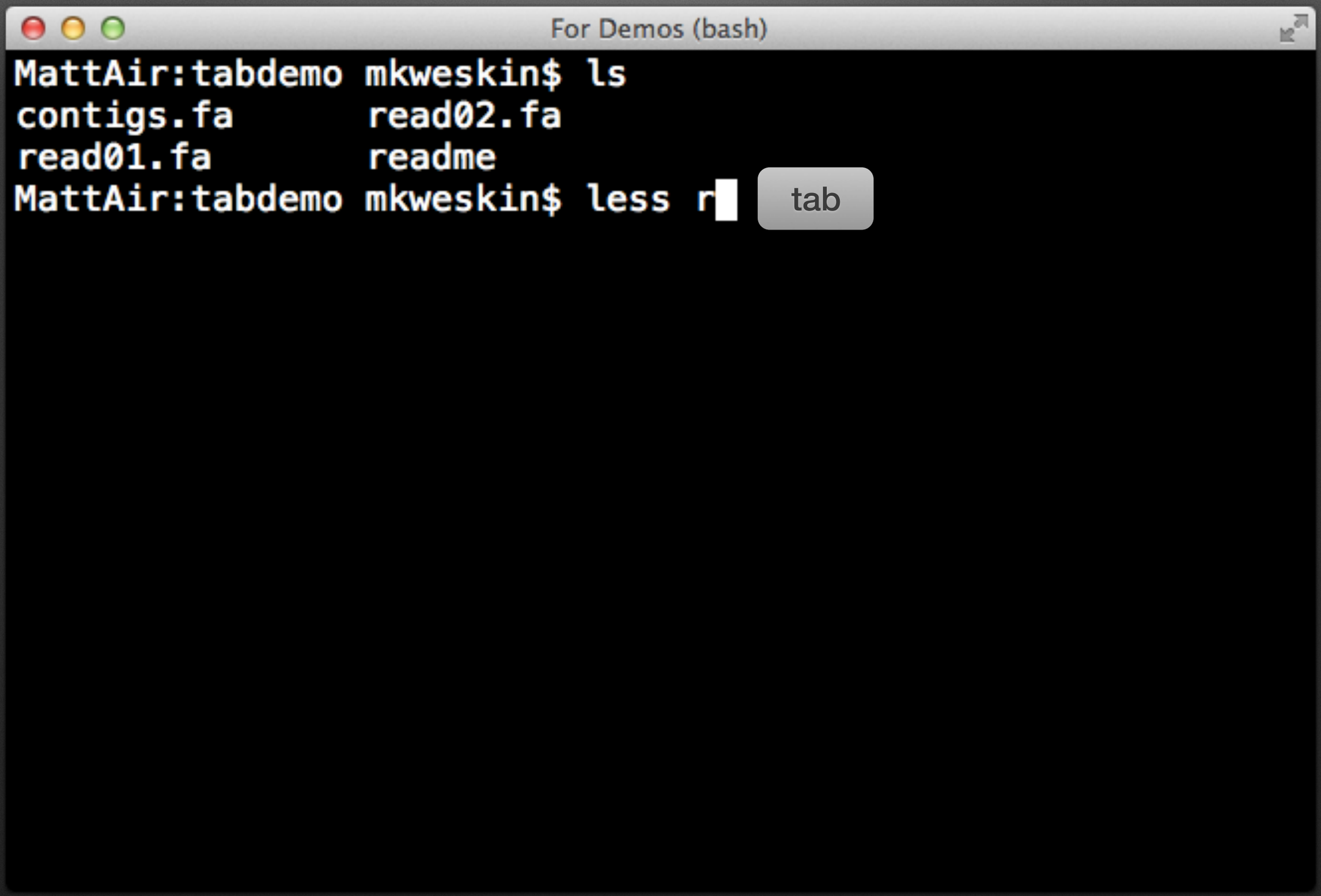
```
$ command -h
$ command -help
$ command --help
$ command
```

- Google! Try: `linux` *`command`*

Tab completion
(will change your life)

- Try it by starting to type a command or file name and then press tab
- Complete a file or command name until there is an ambiguity
- Tab twice to show all options available (in `bash` shell)

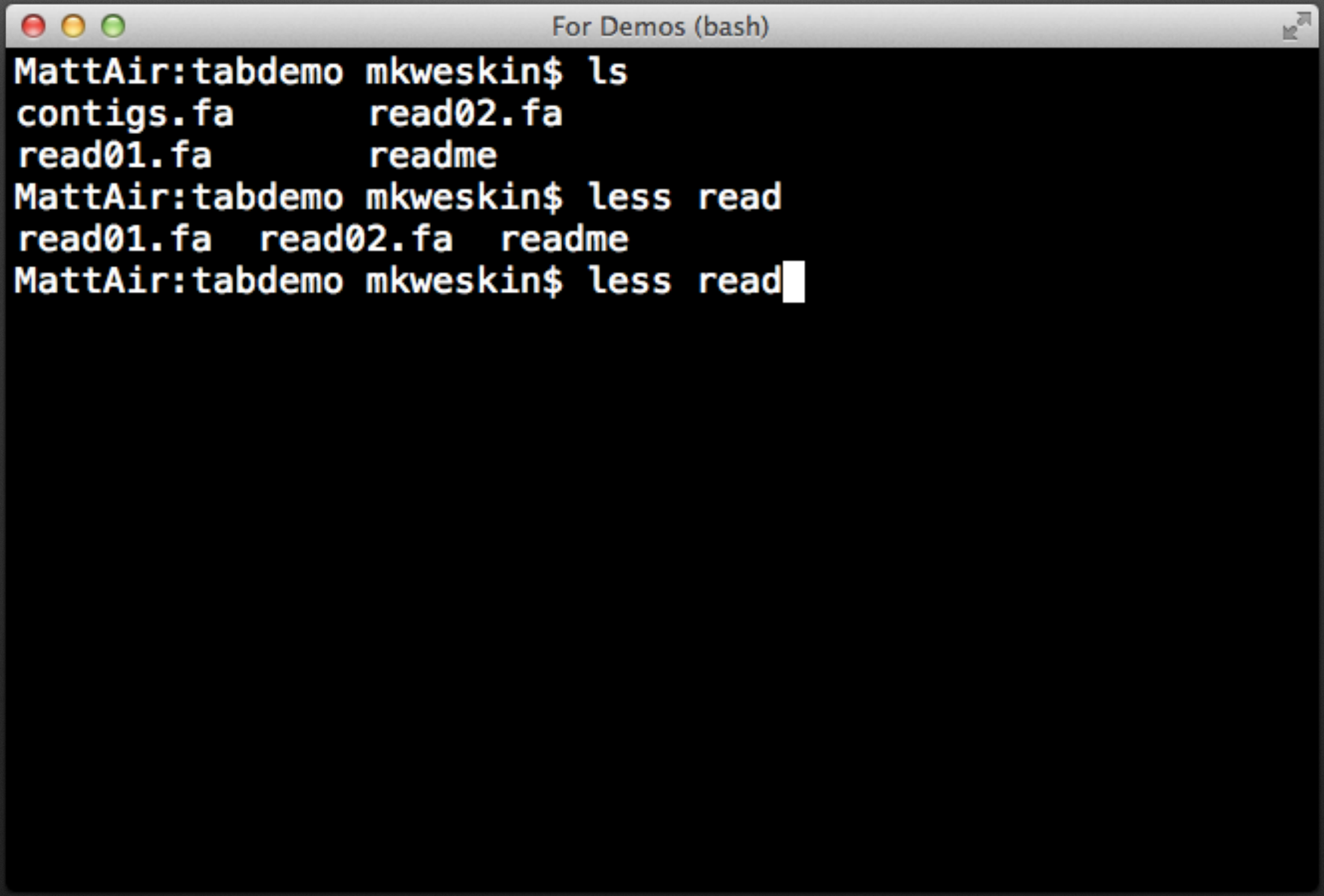

For Demos (bash)
MattAir:tabdemo mkweskin$ ls
contigs.fa read02.fa
read01.fa readme
MattAir:tabdemo mkweskin$

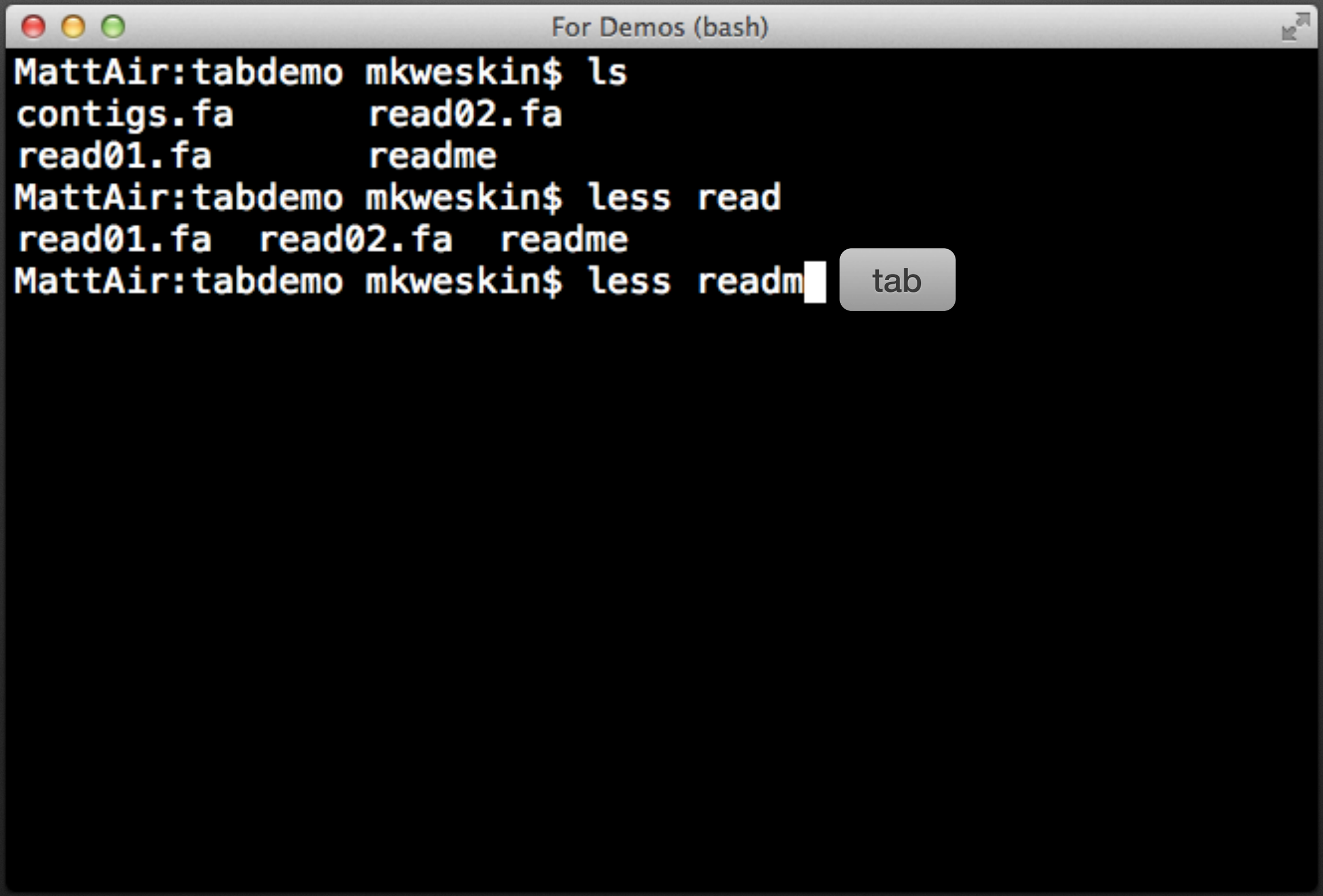

For Demos (bash)
MattAir:tabdemo mkweskin$ ls
contigs.fa read02.fa
read01.fa readme
MattAir:tabdemo mkweskin$ less r
tab

For Demos (bash)

```
MattAir:tabdemo mkweskin$ ls
contigs.fa      read02.fa
read01.fa       readme
MattAir:tabdemo mkweskin$ less read
```

tab tab


For Demos (bash)
MattAir:tabdemo mkweskin$ ls
contigs.fa read02.fa
read01.fa readme
MattAir:tabdemo mkweskin$ less read
read01.fa read02.fa readme
MattAir:tabdemo mkweskin$ less read


For Demos (bash)
MattAir:tabdemo mkweskin$ ls
contigs.fa read02.fa
read01.fa readme
MattAir:tabdemo mkweskin$ less read
read01.fa read02.fa readme
MattAir:tabdemo mkweskin$ less readm
tab

For Demos (bash)

```
MattAir:tabdemo mkweskin$ ls
contigs.fa       read02.fa
read01.fa        readme
MattAir:tabdemo mkweskin$ less read
read01.fa   read02.fa   readme
MattAir:tabdemo mkweskin$ less readme
```

space added automatically
Indicates tab completion is done

Wildcards
(globbing in Unix speak)

- `*` any string (length ≥ 0) of characters

```
$ ls -l *.txt
```

- `?` any one character

```
$ ls -l read0?.fasta
```

- `[abc]` any one character within the brackets

```
$ ls -l read[01].fasta
```

Working with files

`ls` = list directory contents

```
$ ls
Applications   Library
Desktop        Movies
Documents      Music
Downloads      Pictures
Geneious 7.1   Public
```

Common options:

- `-l` long listing: gives file type size and other info
- `-a` list all files including hidden files starting with “.”
- `-t` sorted by time last modified, newest at top
- `-tr` sorted by time last modified, reverse sorted newest at bottom

- Argument: Directory(s) or file(s) to list

cd = change directory

```
$ cd Downloads

$ cd ~/Downloads

$ cd ..
```

- Argument
  - Directory to move to. If you give a file instead you will get an error like this:

```
-bash: cd: foo.fasta: Not a directory
```

`mkdir` = make directory

```
$ mkdir mydir
$ mkdir ../mydir
```

- Arguments
  - Directory(s) to create

`rmdir` = remove directory

```
$ rmdir mydir
$ rmdir ../mydir
```

- Can only delete empty directory (use `rm -r` if full)

```
rmdir: mydir: Directory not empty
```

- Arguments
  - Directory(s) to create

cp = copy file

```
$ cp foo.fasta bar.fasta
$ cp -r mydir ~/Downloads
$ cp ../foo.fasta .
```

- Common options:
  - `-r` recursive copy, include directories. Otherwise error like:

    ```
    cp: omitting directory `mydir'
    ```

  - cp will overwrite current files!
  - `-i` (interactive, prompts before overwrite) 🌻
- Arguments
  - files/directories to copy, Last argument is destination

`mv` = move file

```
$ mv foo.fasta bar.fasta

$ mv mydir ~/Downloads
```

- `mv` will overwrite current files!
  - `-i` (interactive) 🌻
- Arguments
  - file/directory to move
  - Last argument is destination

`rm` = remove file

```
$ rm foo.fasta
$ rm -r mydir
```

- Common options:
  - `-r` recursive, include removing directories. Otherwise error:

```
rm: cannot remove `mydir': Is a directory
```

  - There's no undo, so check twice before using `rm` 
  - Be careful using wildcards. I never use `rm *` 
- Arguments
  - files/directories to remove (can be multiple)

pwd = print working directory

- Shows the full path of your current directory

```
$ pwd
/pool/cluster0/workshop
```

Stuck in a command

- `<control+c>` Will usually kill current program, sometimes `<control+d>`
- If that doesn't work (emacs, vi, less) Google: quit vi or `<control+z>` to suspend program (but then you have to kill it)

Viewing text files

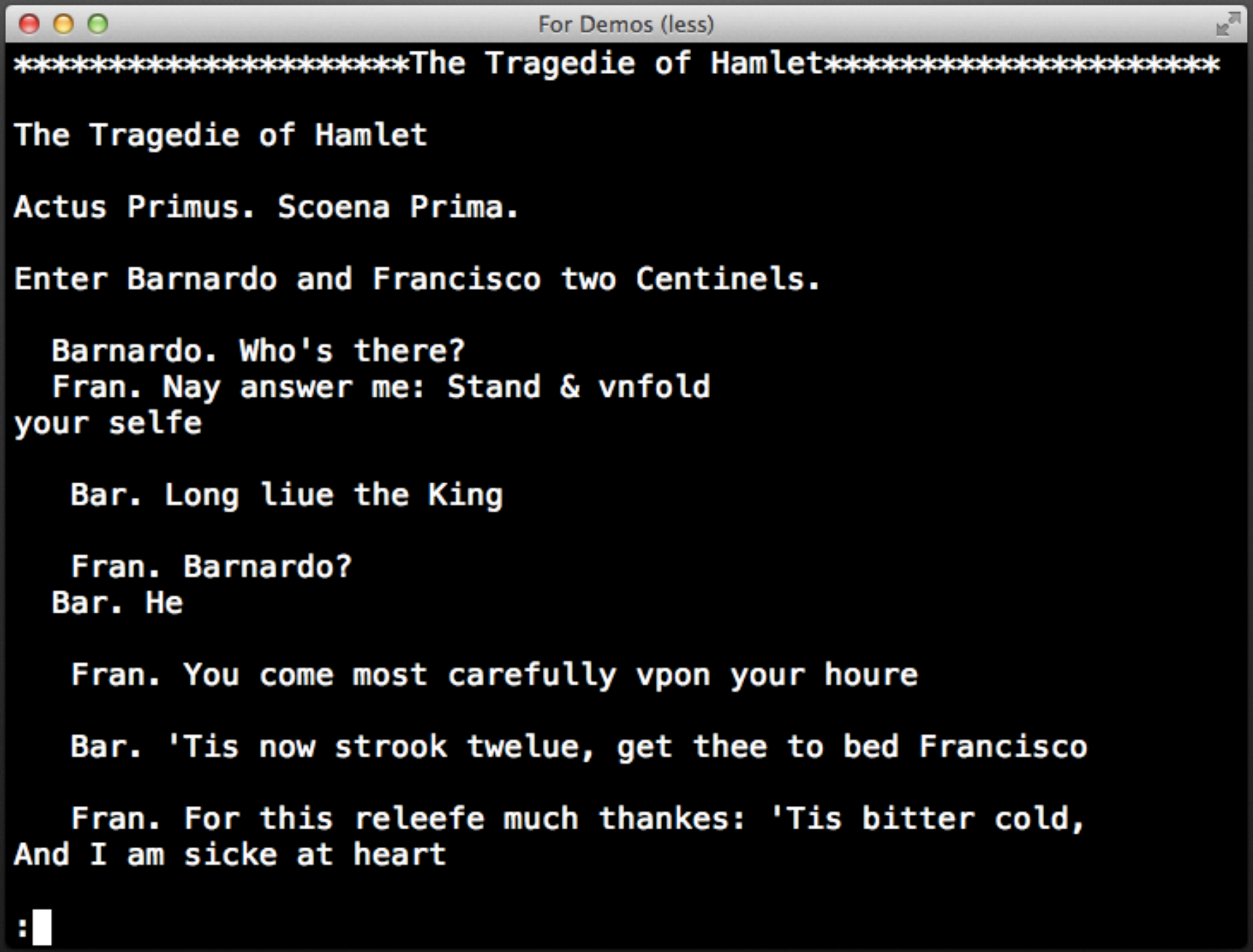
Viewing full files
`cat` and `less`

- Show FULL contents (or concatenate several files)

```
$ cat file
```

- Show file one screen at a time (one command, two names)

```
$ less file

$ more file
```


For Demos (less)
**********The Tragedie of Hamlet**********
The Tragedie of Hamlet
Actus Primus. Scoena Prima.
Enter Barnardo and Francisco two Centinels.
Barnardo. Who's there?
Fran. Nay answer me: Stand & vnfold
your selfe
Bar. Long liue the King
Fran. Barnardo?
Bar. He
Fran. You come most carefully vpon your houre
Bar. 'Tis now strook twelue, get thee to bed Francisco
Fran. For this releefe much thankes: 'Tis bitter cold,
And I am sicke at heart
:

`less` = interactive file display to screen

```
$ less foo.fasta
```

- Single key commands when running:
  - `q` quit
  - <space> forward one screen
  - <arrow up> <arrow down> move up/down one line
  - `/word` search for “word” in document (case sensitive)
    - `-i` to make case insensitive
  - `G` bottom of document
  - `gg` top of document

Viewing files- `head` and `tail`

- First 10 lines of file `$ head file`
  - `-<number>` to specify number of lines to show
  - e.g. `$head -40 myfile`
- Last 10 lines of file `$ tail file`
  - `-<number>` to specify number of lines to show
  - e.g. `$tail -10 myfile` or `$tail -10 job*.out`

Editing text files

Editing/creating text files

- You can edit and create files directly from the command line (on the remote system)
- `nano` easiest to get started with
- `vi` “pro” text editor, also see `emacs`
- `emacs` “pro” text editor, also see `vi`

`nano` = play on `pico`

```
$ nano foo.fasta

$ nano newfile.fasta
```

- Can edit a file or create a new file
- Arrow keys to navigate
- Use `<control+letter>` options at bottom (^=control-key)
  - `^x` = <control+x> exits
    - Will prompt to save changes “Save modified buffer”, type y to save and then return to use the same name

bio_user@hydra-3:~/Day1/data (ssh)

GNU nano 2.0.9 File: ecoli_ref-5m_small.fasta

```
>EAS20_8_6_1_3_1486/1
GGGGTAACGGCTCACCTAGGCGACGATCCCTAGCTGGTCTGAGAGGATGACCAGCCACACTGGAACTGAGACACGG$
>EAS20_8_6_1_3_1671/1
GCGGTGTTGGCGAAATAAGCGAAAACGAGGAGATAAACAATGAGTCAAACCATAACCCAGAGCCGTTTACGCATTG$
>EAS20_8_6_1_3_300/1
GTTGATTCGCCAATAACCTTAAGCATTTGATTACGGAATCGTAAAATGAAGCAGTTTCTTGATTTTTTACCGCTGG$
>EAS20_8_6_1_3_1543/1
TATCTTGAAAAGCTGGGCGTTGAGTACAAGATTGTTGAAGAGAATACTTACGGTATCGTGAAAGAGAAGATTCCAG$
>EAS20_8_6_1_3_224/1
TTATGGGTCGCGATTGCCGACGTCAGCTACTATGTGCGTCCGTCAACGCCGCTGGACAGAGAAGCGCGTAACCGTG$
>EAS20_8_6_1_3_238/1
TGACTATAATAATAGACGTTCTTTGTTCCTTGCTTTGCTAATACGCCCACAAACTCTGTAAATTAATGTATGAATA$
>EAS20_8_6_1_3_95/1
GCGTGTTCCTGGGTTTGCACGCGGGCGGTGATGTCATCTTCCGAATCACCAGCAAATACCGGGACTTTCGCCTGTA$
>EAS20_8_6_1_3_1184/1
CCATCAGCTTGTTGTCTTTCGCTGCCGTTTCGCACAACCAGTCGCCAAAGATTTTTGAATAGCTCGGCAAACCGCC$
>EAS20_8_6_1_3_900/1
CGCGCGGTATTGATGTCGGGGCGAAGTTTGAAATTTATCAGTTAATTGCCGAACTGGCGAAGAAAGGCAAGGGGAT$
>EAS20_8_6_1_3_677/1
```

[Read 200000 lines]

^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur Pos
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCut Tex ^T To Spell

echo = display text to output

```
$ echo “Hello world”
Hello world
```

- Display text to screen
- Why?
  - useful in scripting
  - Display variables ($PATH)

`which` = which directory is this command found?

```
$ which mkdir
/bin/mkdir
$ which java
/usr/java/latest/bin/java
```

- Shows location of the command being used to make sure it’s the right version

Hands-on #1-4

grep:
global regular expression print

🐢 grep searches input files for a search string and prints the lines that match it

grep reads through your file from the beginning,
copies a line into a buffer,
compares it against the search string,
and if the comparison passes,
prints the line to the screen

grep example

Redirecting and Pipes

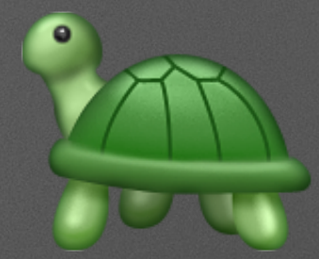
Redirecting

> (redirect operator) creates a file
>> (append operator) appends to the file
>& redirects stderr and stdout to a file

great for creating log files

```
/apps/allpaths-lg-old/bin/RunAllPathsLG PRE=/pool/genomics
DATA_SUBDIR=M_zebra REFERENCE_NAME=fish RUN=run1 THREADS=24
OVERWRITE=True > fish_5_19.log
```

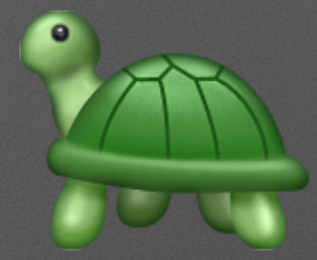
Using pipes



- A pipe is a form of redirection that sends the output of one program to another program for further processing
- Redirection is the transferring of standard output to some other destination, such as another program, a file or a printer, instead of stdout
- Pipes create temporary direct connections between two or more simple programs

```
command_1 | command_2 [| command_3 . . . ]
```

Using pipes



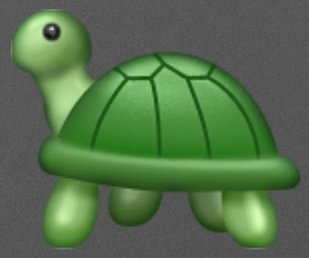
simple example: pipe the standard output of one program to the standard input of another program

```
ls -l | grep ‘rwx’
```

you will see all of the files in the working directory whose permissions (or name) contain the letters rwx in order

- ‘ls’ lists files to its standard output
- ‘grep’ takes its input and sends any lines that match a particular pattern to its standard output
- the pipe operator (|), which tells the shell to connect the standard output of ls to the standard input of grep

tar and gzip



🐢 `tar` archive a file system:

`[-c]` create new archive
`[-x]` extract to disk
`[-z]` zip/unzip with gzip
`[-v]` verbose
`[-f]` file

```
$ tar -cvf hello.tar hello.txt hello.md hello.py
result: hello.tar
```

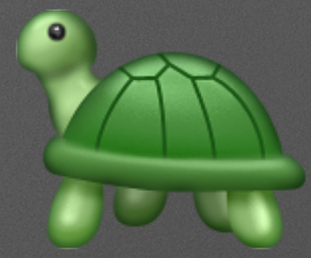
🐢 `gzip` compress and replace with a .gz file

```
$ gzip hello.tar
result: hello.tar.gz
```

🐢 Do it all in one command

```
$ tar -cvzf hello.tar.gz hello.txt hello.md hello.py
```

tar and gzip



🐢 `gunzip` uncompress a .gz file

```
$ gunzip hello.tar.gz
result: hello.tar
```

🐢 `tar` unpack a tarball

```
$ tar -xvf hello.tar
result: hello.txt, hello.md, hello.py
```

🐢 Do it all in one command

```
$ tar -xvzf hello.tar.gz
```