Introduction to Linux for Bioinformatics

The structure of Linux

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Meet your Linux system

We'll explore how a Linux system is organised
– into drives
– into partitions
– into folders
– into files

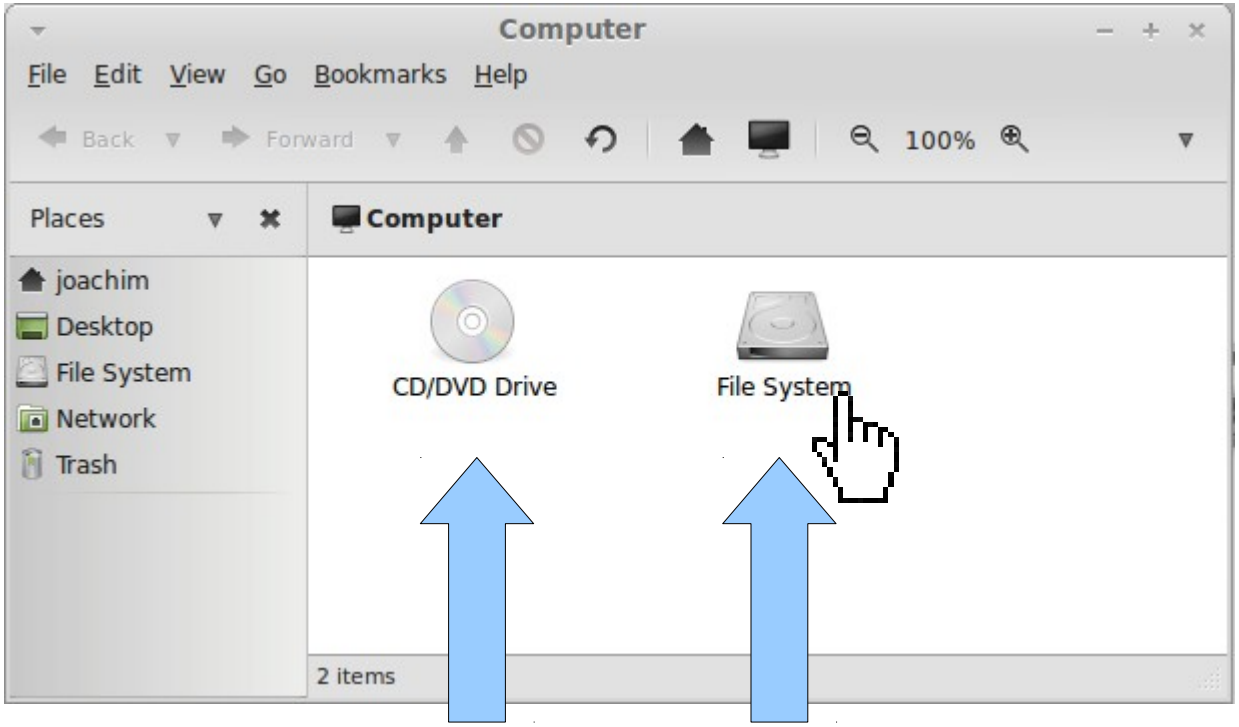
One of the most basic tasks in bioinformatics is handling and storing of big data.

Meet your Linux system

Follow a along: open 

on the desktop.

('Computer' is specific for Linux Mint, won't find it on other Linuxes)

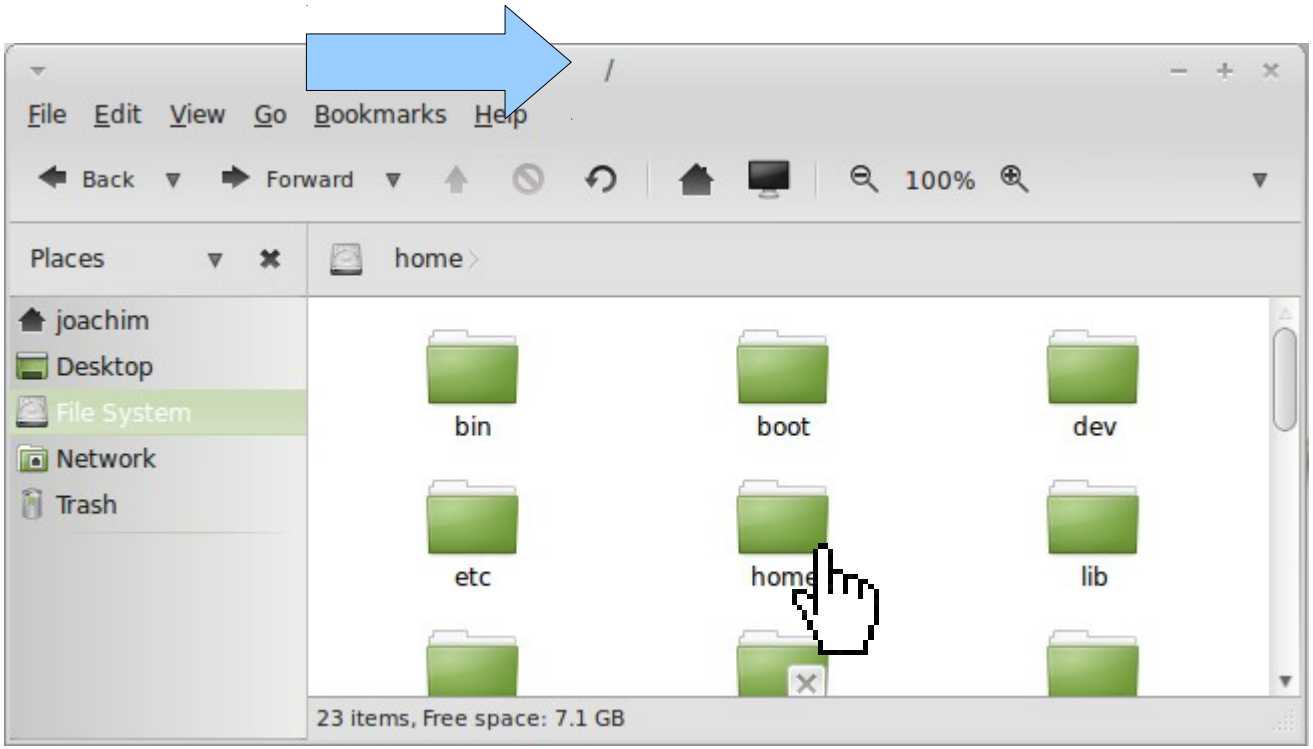


Read the contents of a CD/DVD

Read the hard disk

The root directory

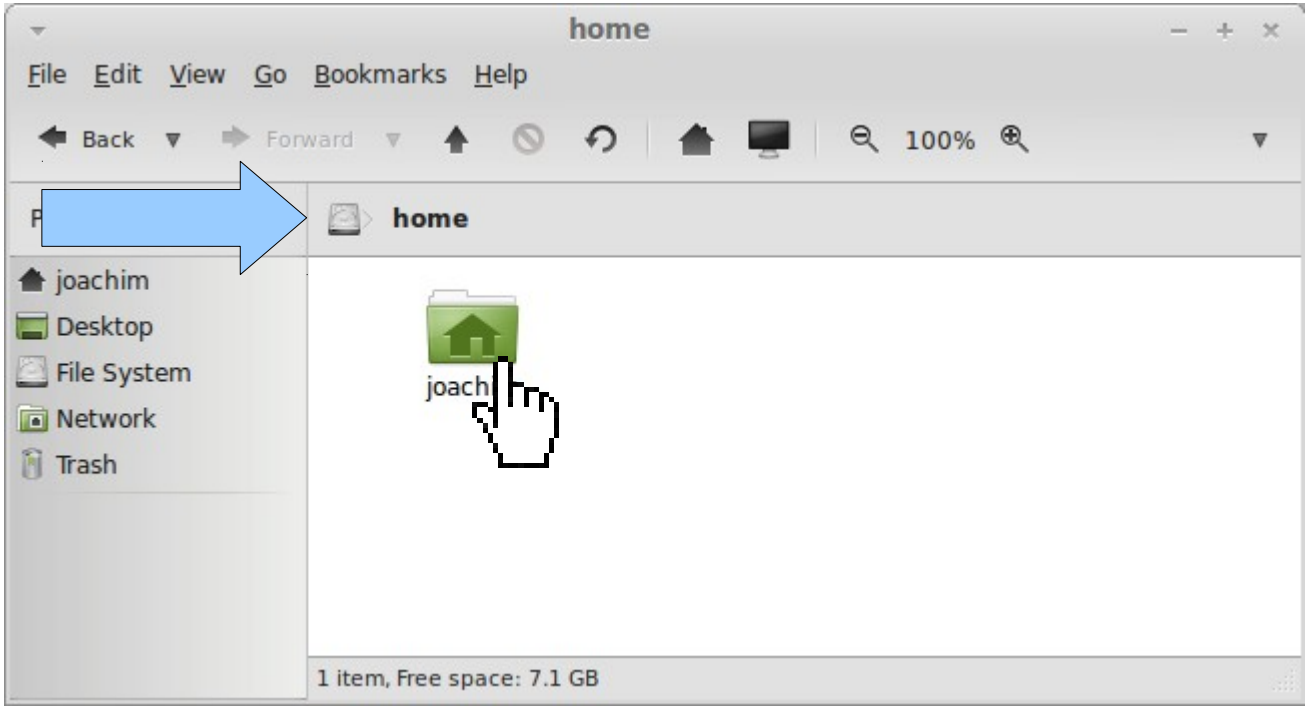
The disk on your computer, which has Linux installed on, is called **/** or the **root** directory. It is the start of the file system.
Now enter the folder home.



The home folder

One of the folders under the root directory is called **home**.

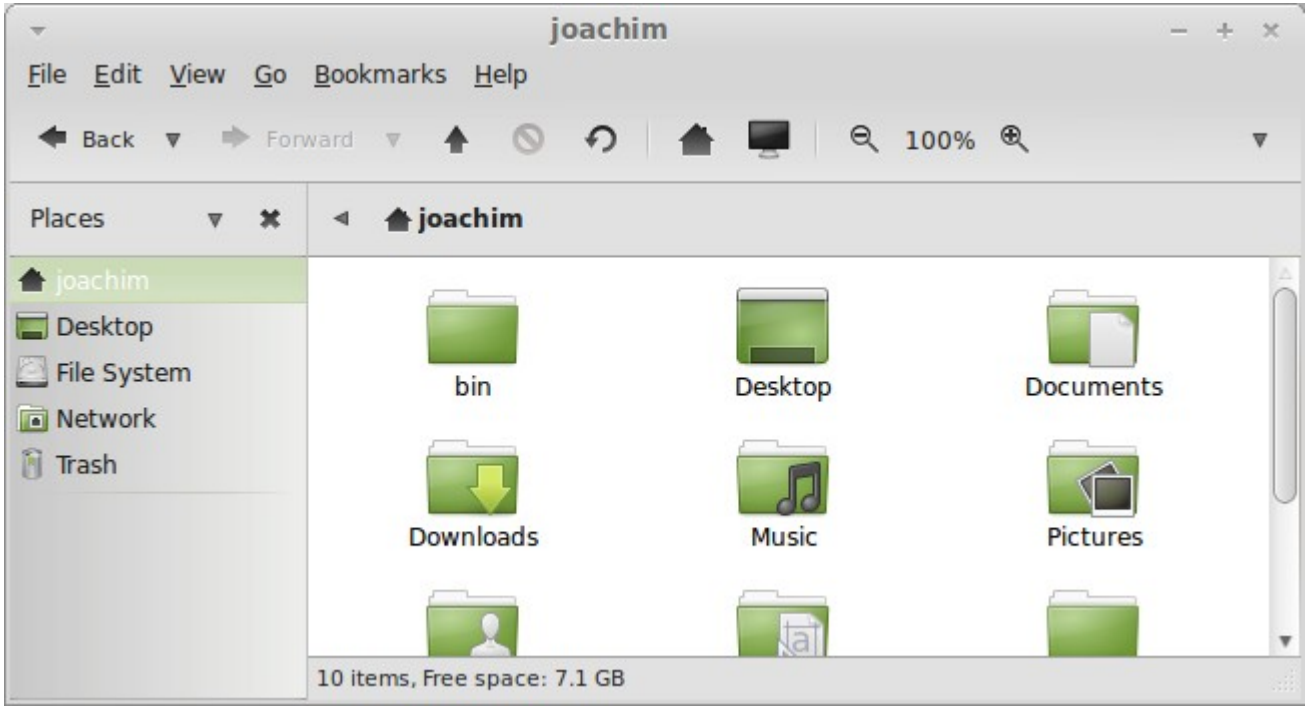
Every user on the system (server or PC) has one directory in /home. Locate yours and double-click on it.



Permissions in your home

Linux is very secure. **Only** in **your own home** folder you can **create** files and folders, usually not anywhere else.

Anywhere else is reserved for the administrator ('root')

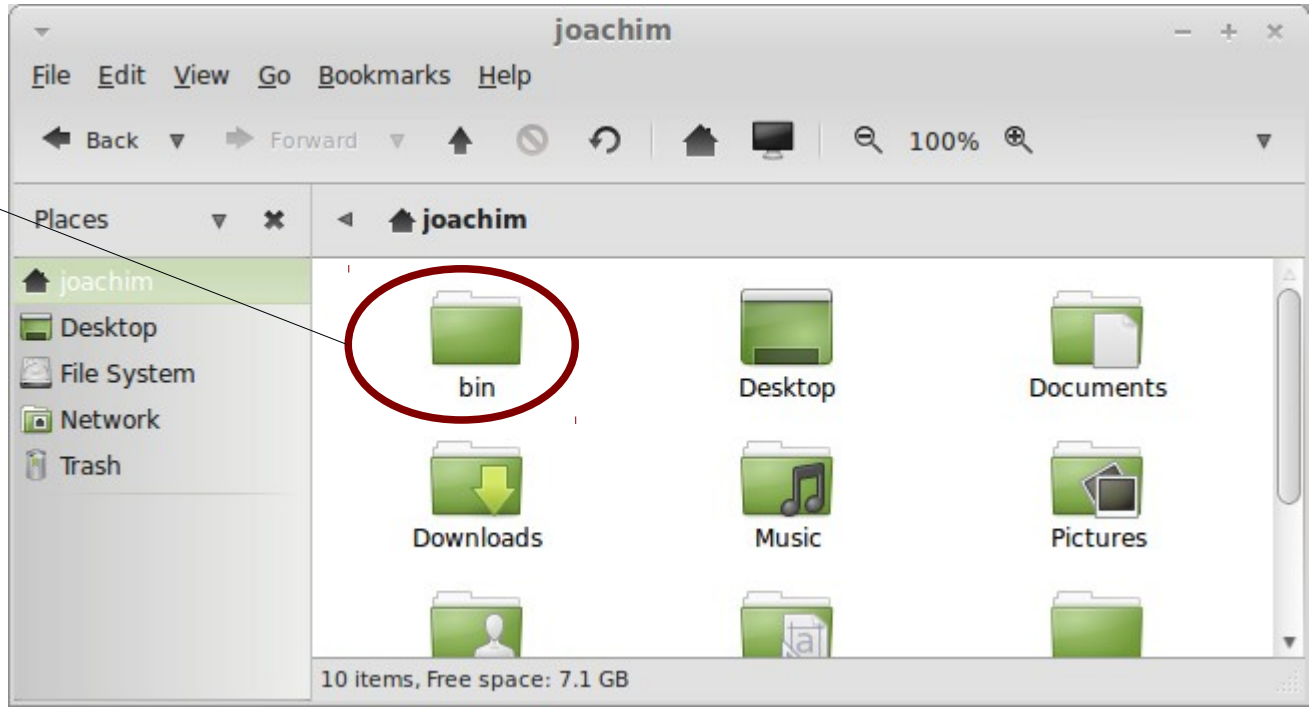


Create the folder bin in your home

Use the mouse (right-click), or press ctrl+shift+n, or, go via the File menu.

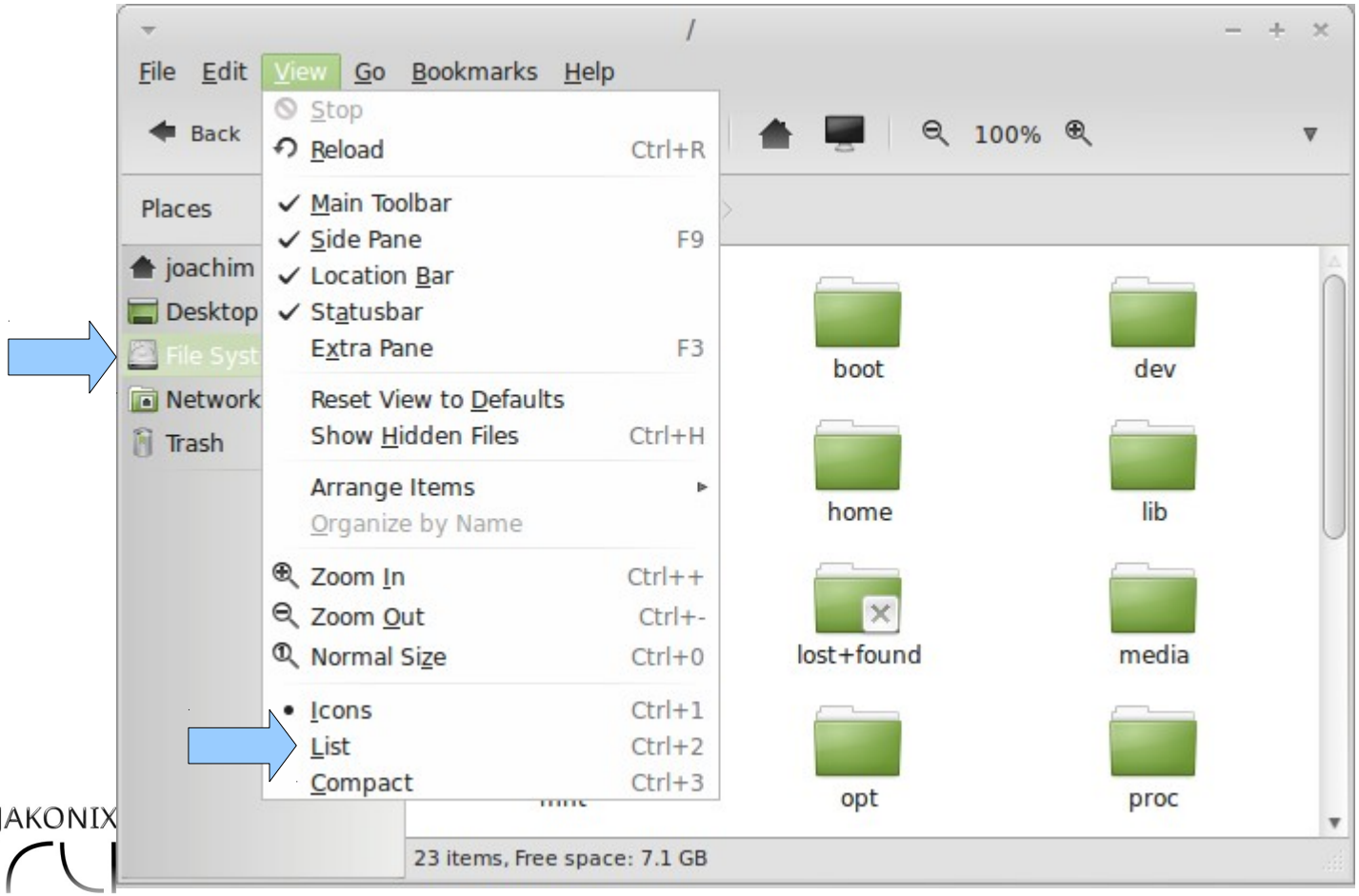
Create the folder bin. Later, we will put scripts in this folder.

Create this folder



Visualize the tree structure

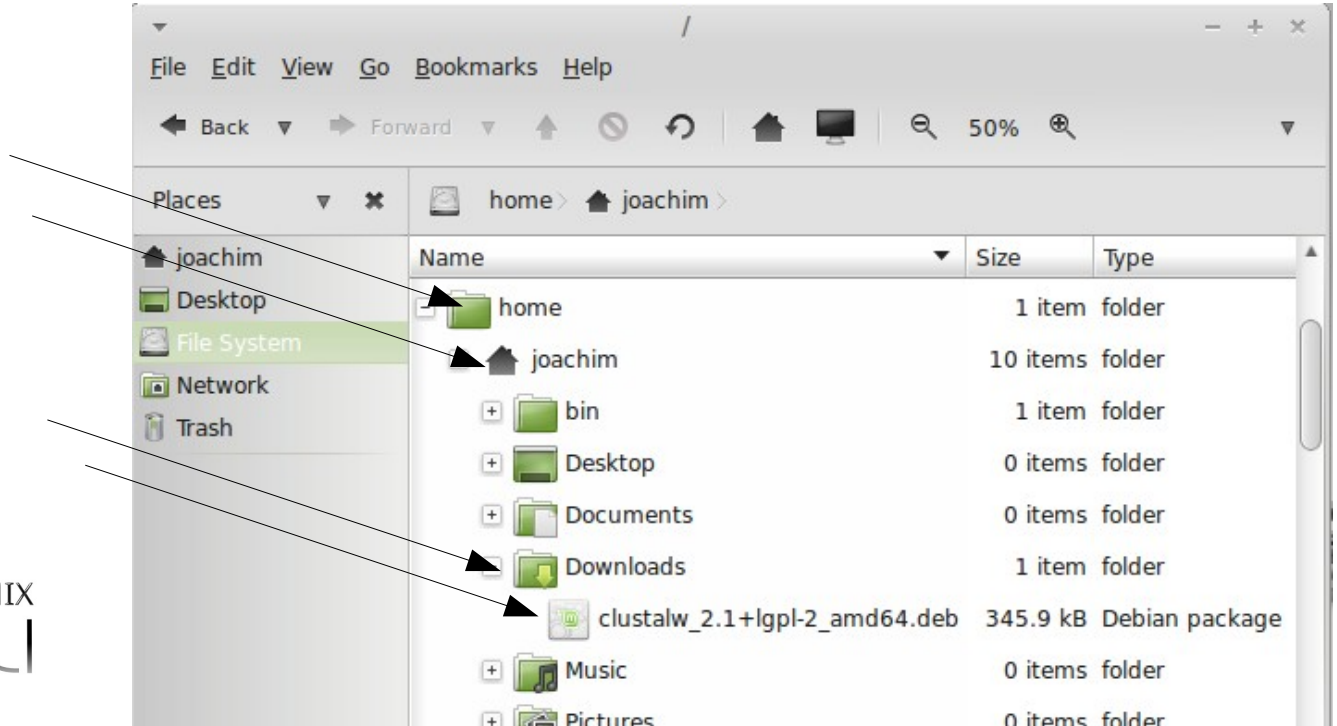
Go back to the root directory. Change the **view to 'List'.**



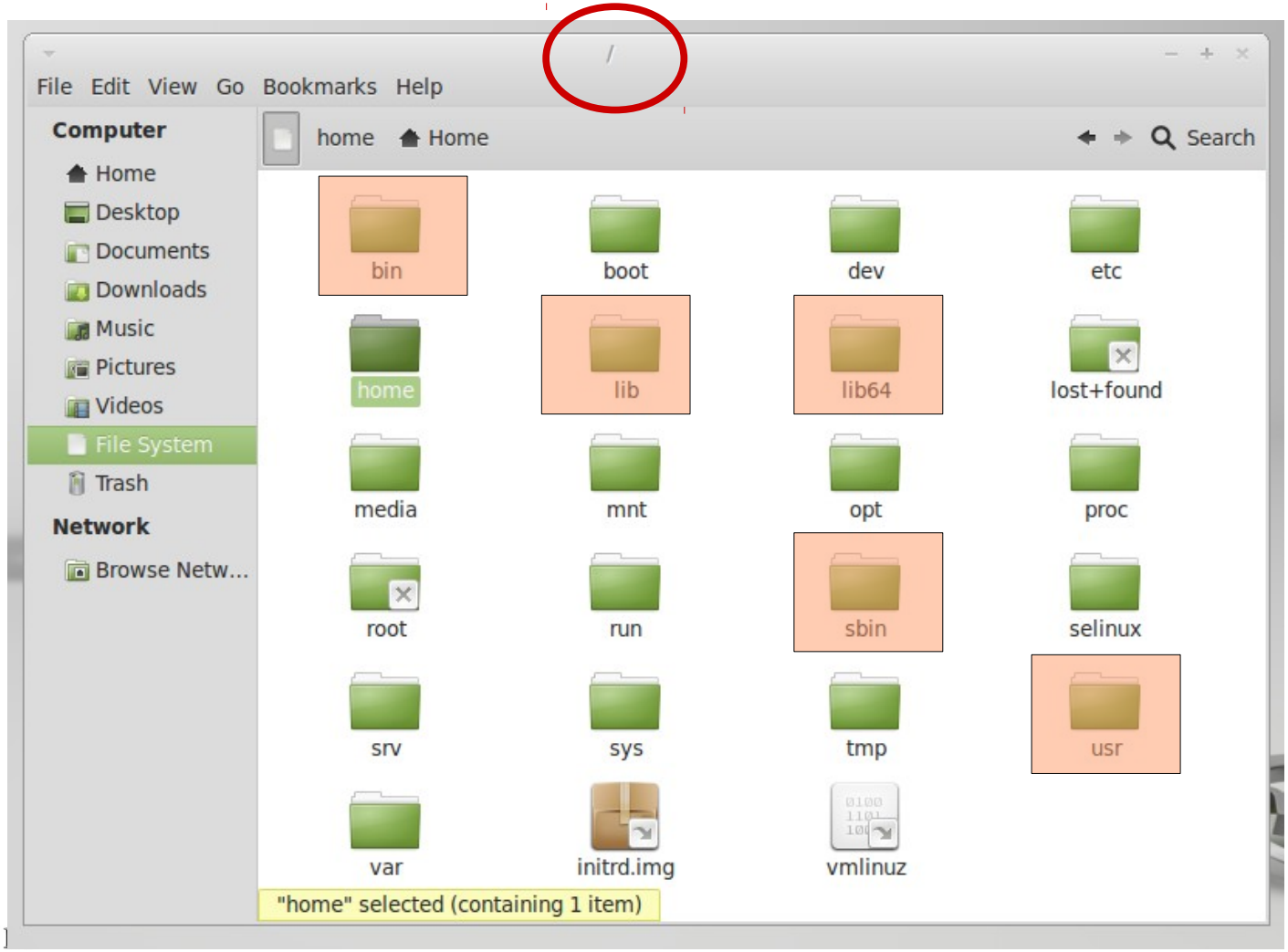
Visualize the tree structure

Clicking on the '+' expands the contents of that folder. You can do this for every subfolder too. A **path points to a location of a file or folder.** It is separated by a **'/'** symbol.

/home/joachim/Downloads/clustalw_2.1+lgpl-2_amd64.deb

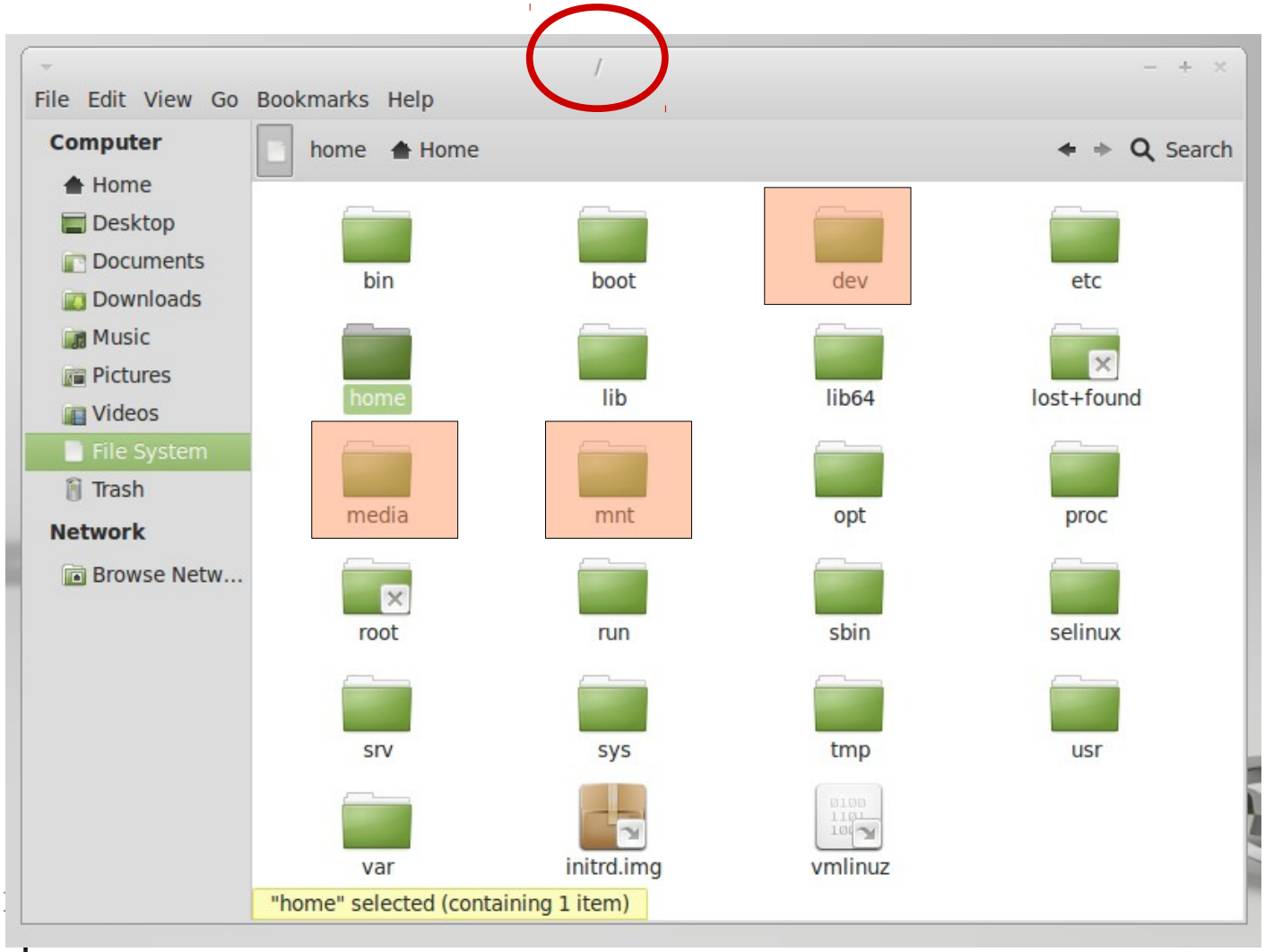


The program file's location

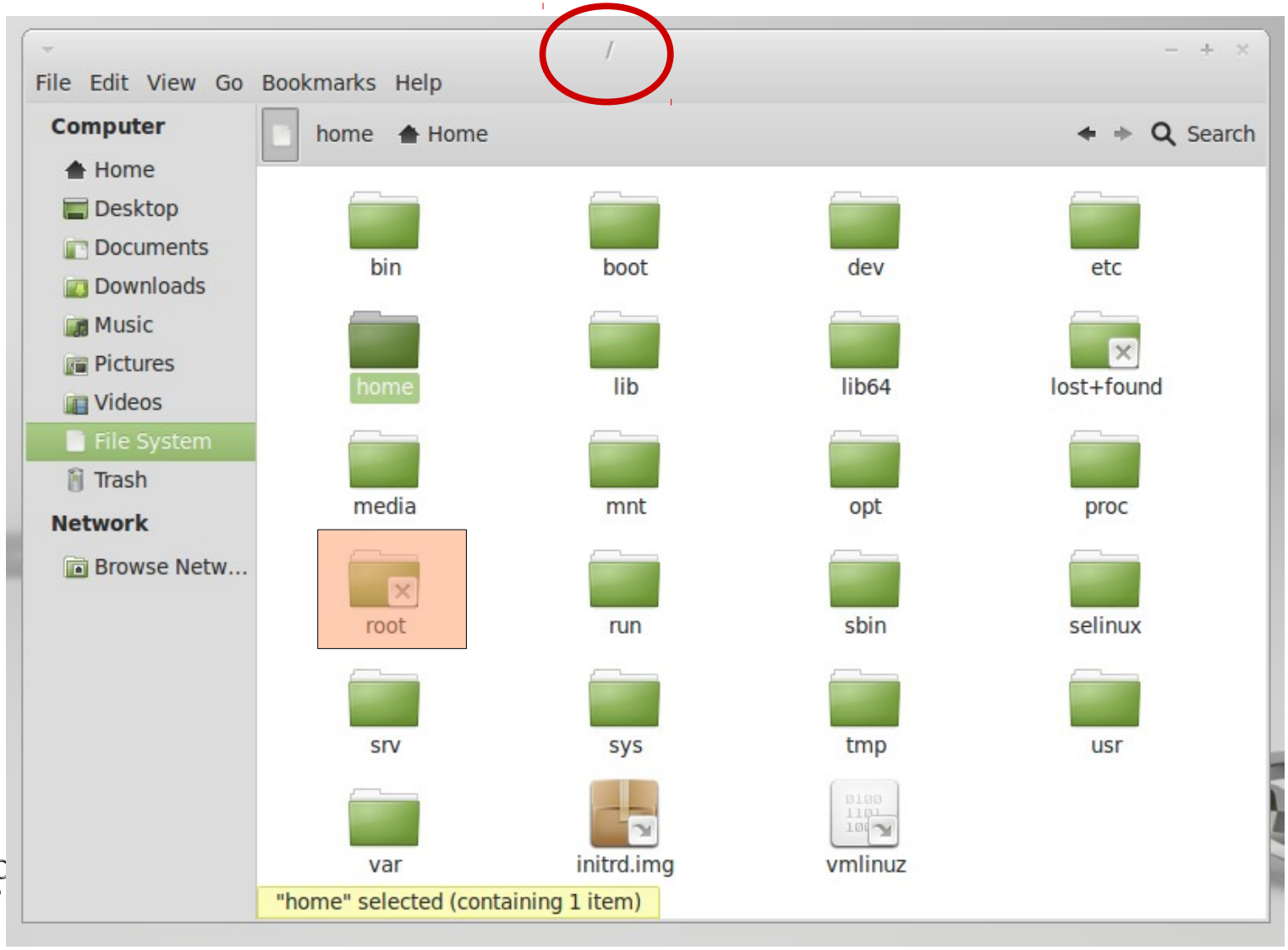


Contain 'program' files

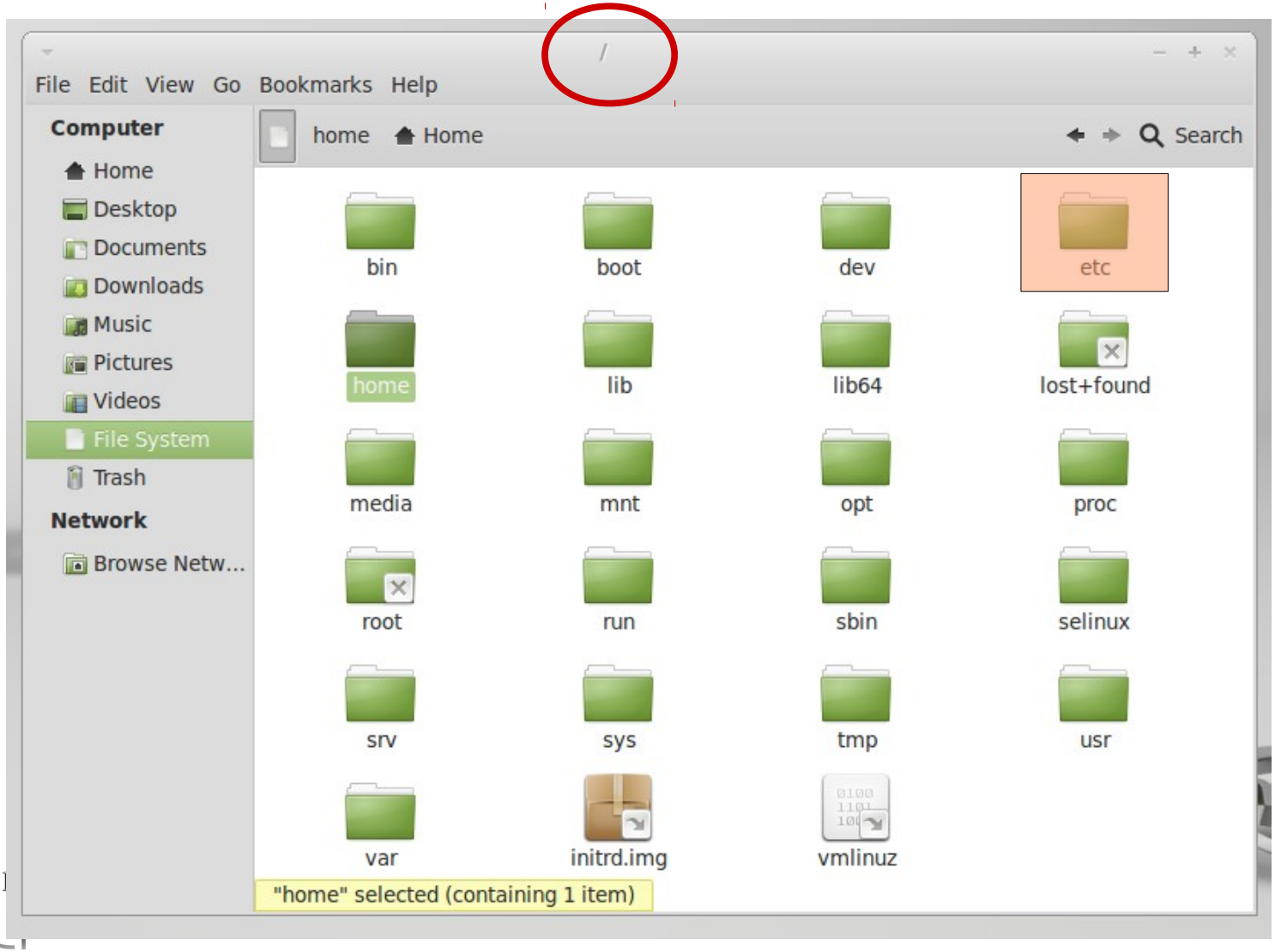
Disk and shares information



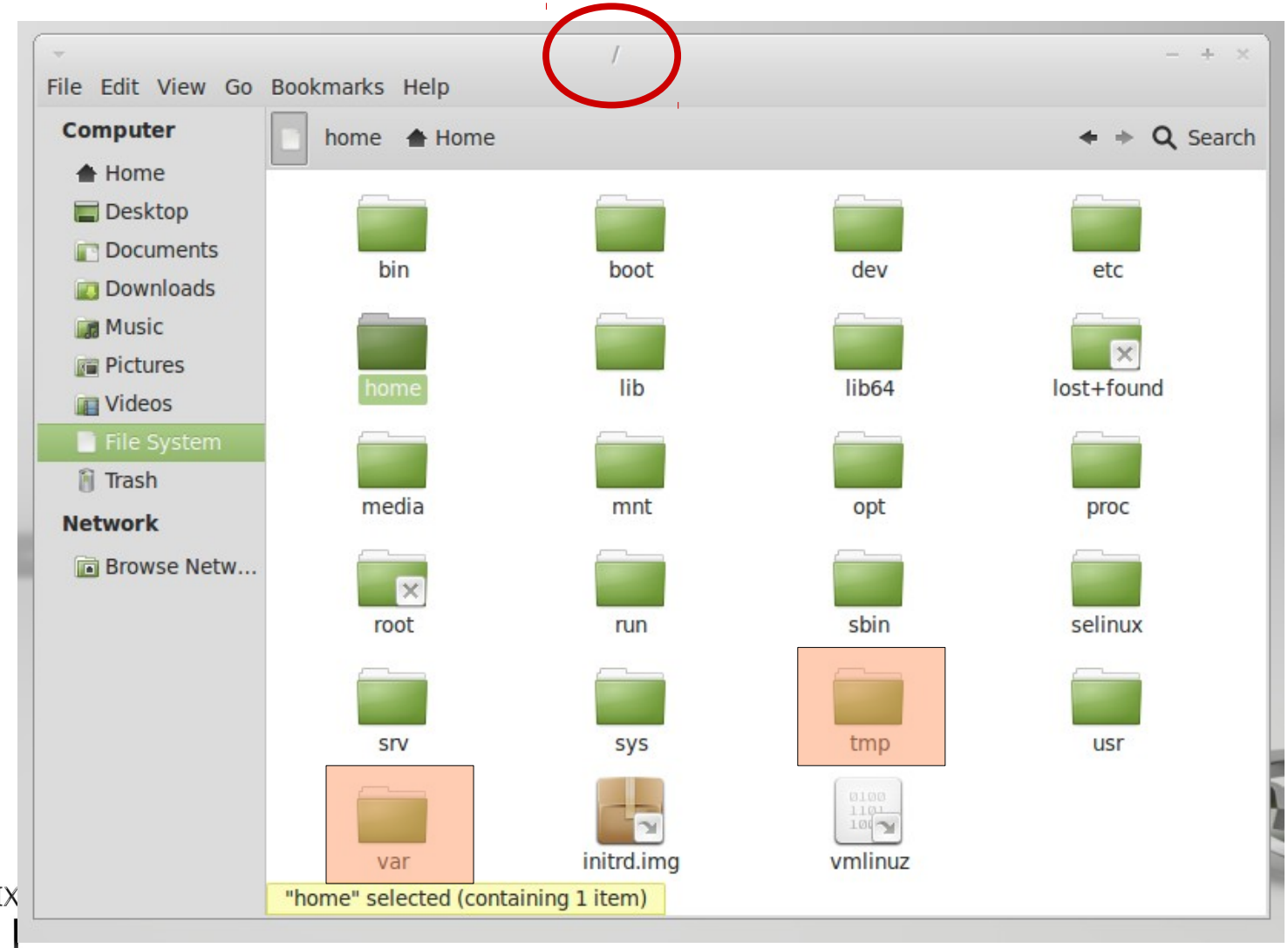
The administrator's home



Configuration files



Quickly changing content



'Everything is a file in Linux'

/dev/sda

/proc/meminfo

/dev/mouse1

/dev/input1

"Everything is a **file** in linux": **devices**, and their statuses are accessible by reading the contents of the paths to the respective files.

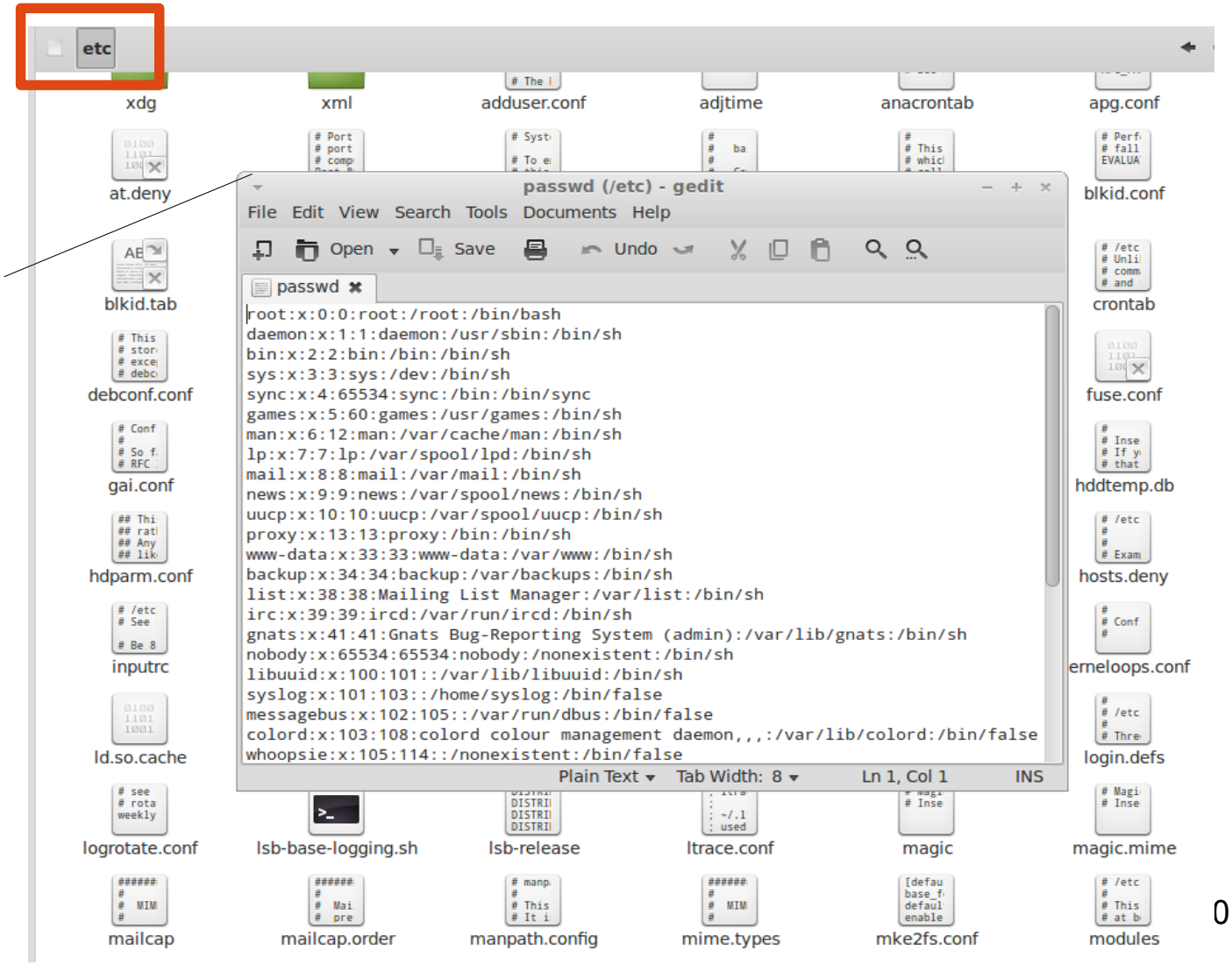
Note: but only *text files* can be displayed in human readable format in text editors.

http://tldp.org/LDP/intro-linux/html/sect_03_01.html

http://en.wikipedia.org/wiki/Everything_is_a_file

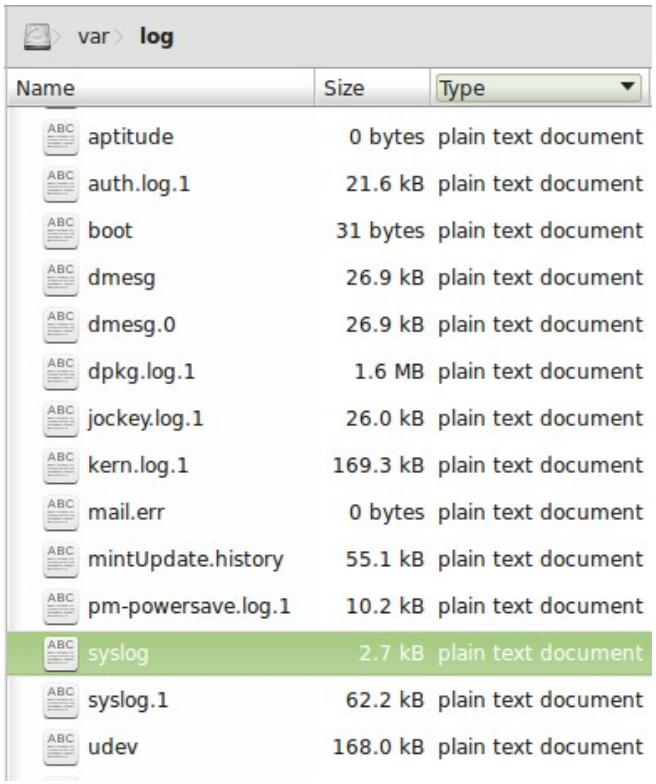
Configurations are in plain text files

The text file **/etc/passwd** contains info about the users on your system

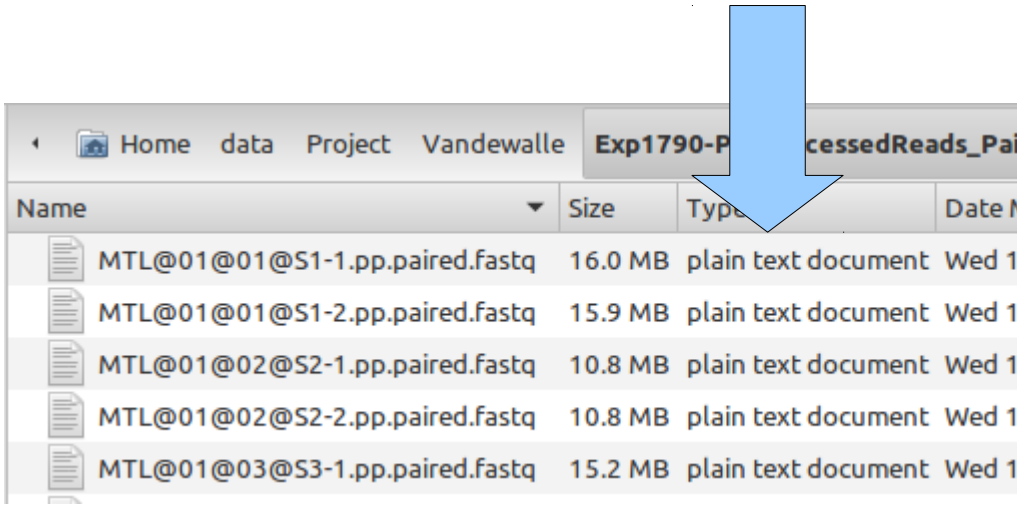


Natural fit of bioinformatics and Linux

Because of this amount of text, Linux comes with a lot of **command line** tools to manipulate / search / analyse text files.



Similar to Bioinformatics, which stores data also pre-dominantly in **large text** files.



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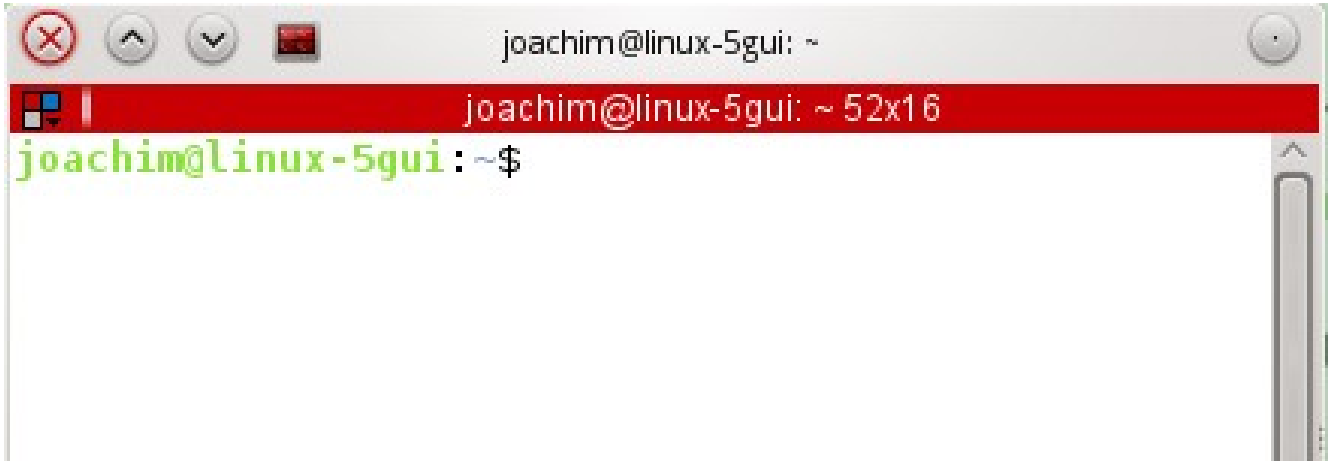
Natural fit of bioinformatics and Linux

All configurations of the system or programs in Linux are stored in **text files**.

The main tool to process these text files is the **terminal**, a program that gives you but a prompt.

Where does the terminal originates from?



Using the terminal as a solution

Before the rise of the nice desktops, users had only this:

Press ctrl + alt + F1

This means – users needed to navigate around on their computers, read files, create files, print, run programs, play games,... **all from the command line.**

And yes, this is possible.

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Using the terminal as a solution

Before the rise of the nice desktops, users had only this:

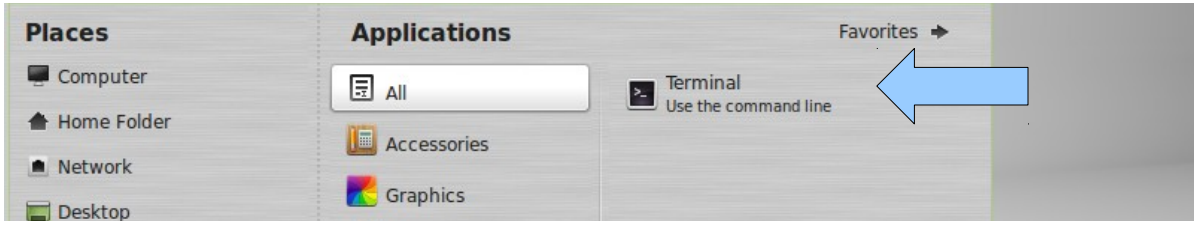
Press ctrl + alt + F1

(Lesson one in using Linux. Tux is friendly, but strict.)

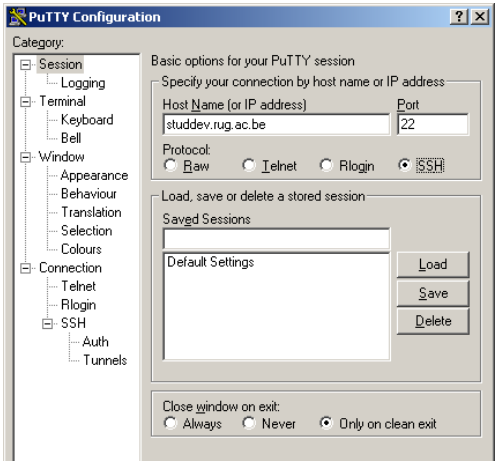
Press ctrl + alt + F7

More practical: use a terminal program

- Open a terminal program using the menu, and execute commands on your computer:



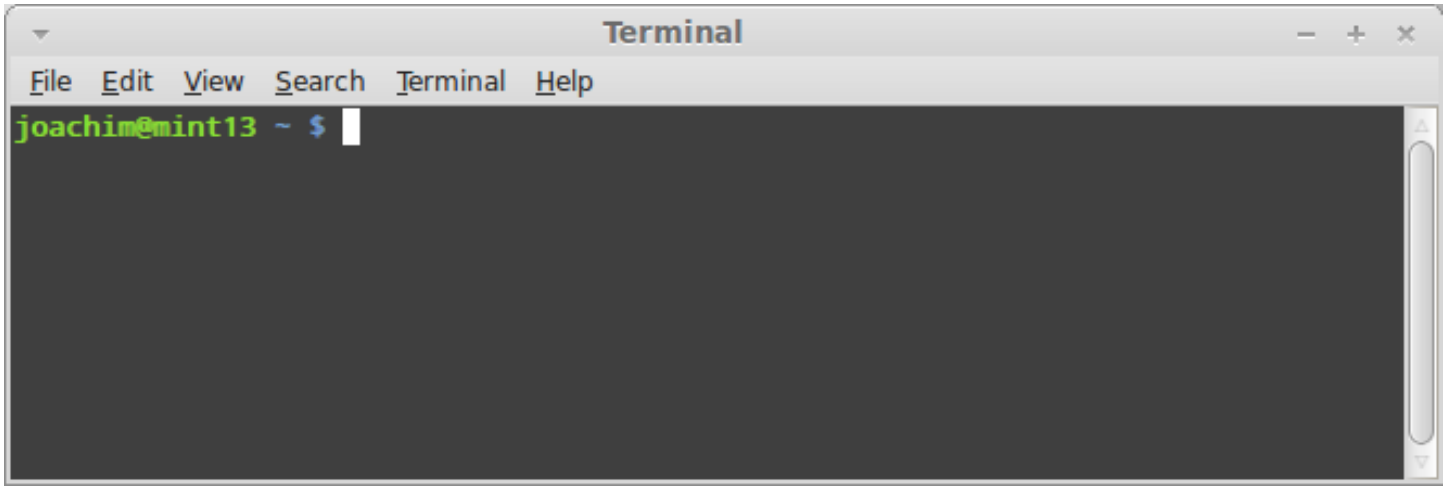
- Also possible: connect to a terminal over the internet, e.g. using Putty program installed on a Windows machine.



http://www.putty.org/

Your first steps in a terminal

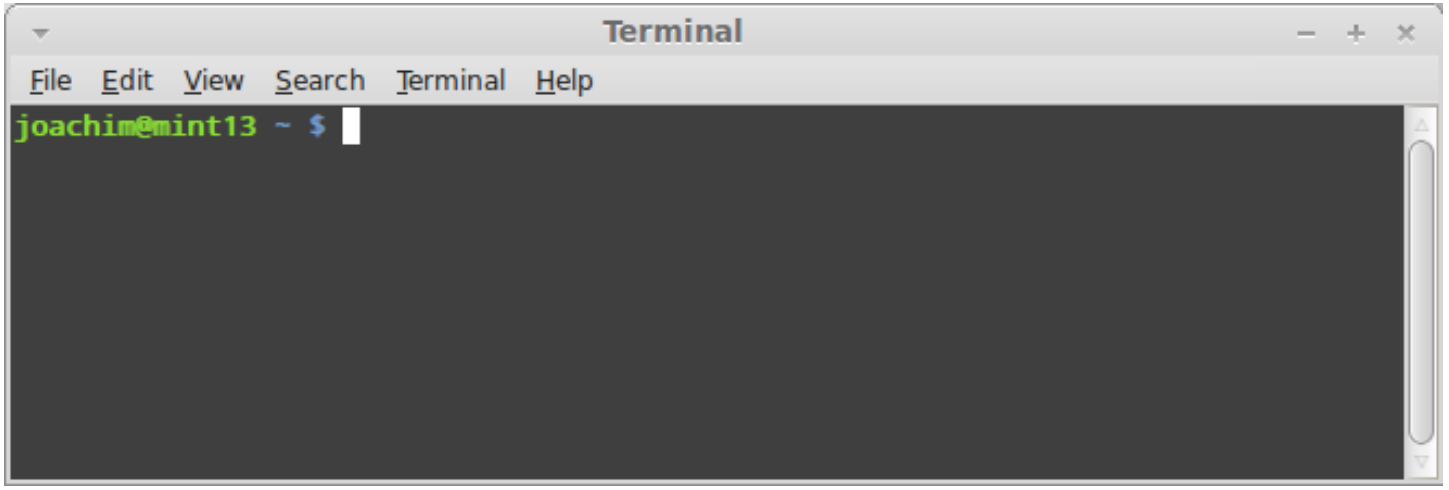
Starting a terminal, we end up with this:



A terminal accepts only input from the keyboard, the command line. You can only type. What you type gets interpreted by the program **Bash**, which will then do what you ask.

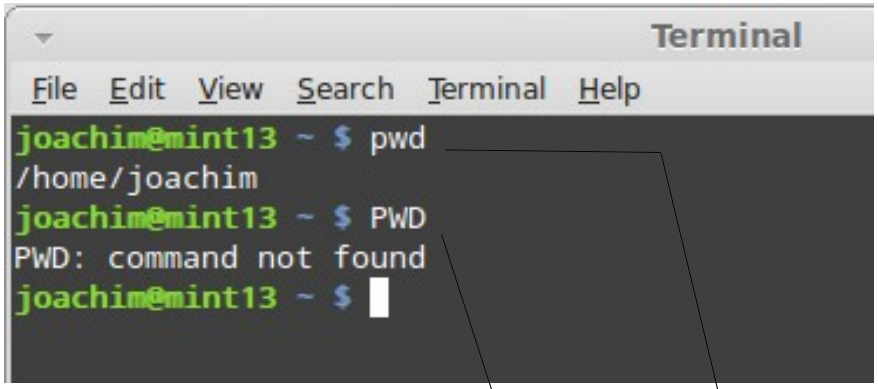
http://en.wikipedia.org/wiki/Bash_%28Unix_shell%29

Few important things



- A command line is always positioned **somewhere in the file system**.
- What you type is **case-sensitive**
- The prompt line can be customized, but by default it shows:
  - Username
  - @
  - Machinename
  - Current location ('working directory'),

Check where your shell is positioned

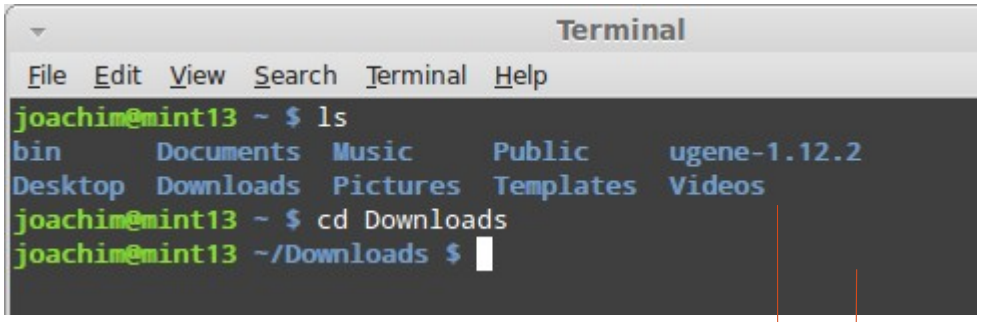


...

After typing your command, press **<enter>** to execute a command.

pwd = print working directory

Navigating in the file system

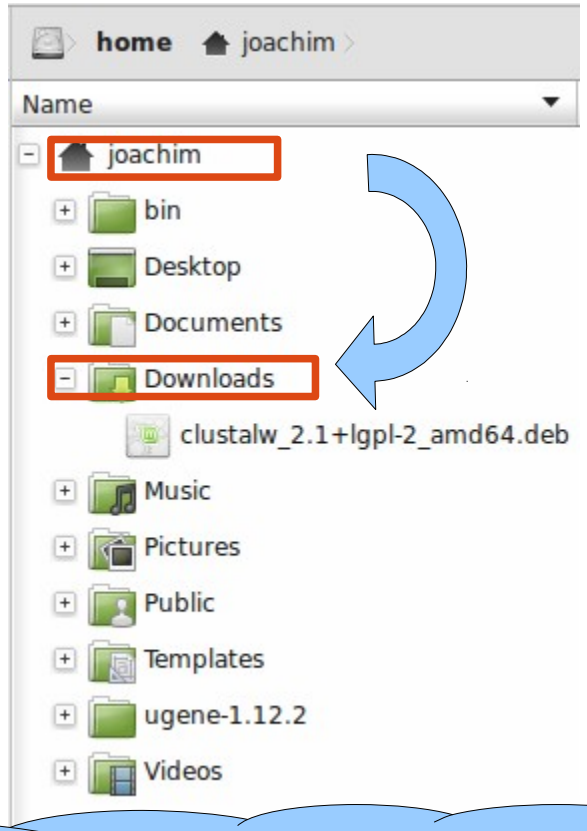


ls = list contents of current directory

cd = change to this directory

The word after 'cd' matches a directory. We tell 'cd' to go to this directory. This Additional word is called an **argument**.

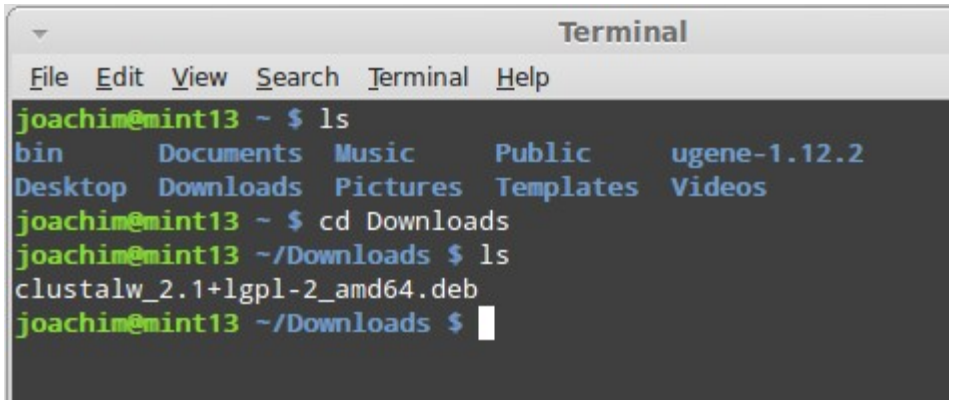
The result is that the prompt has changed position from:

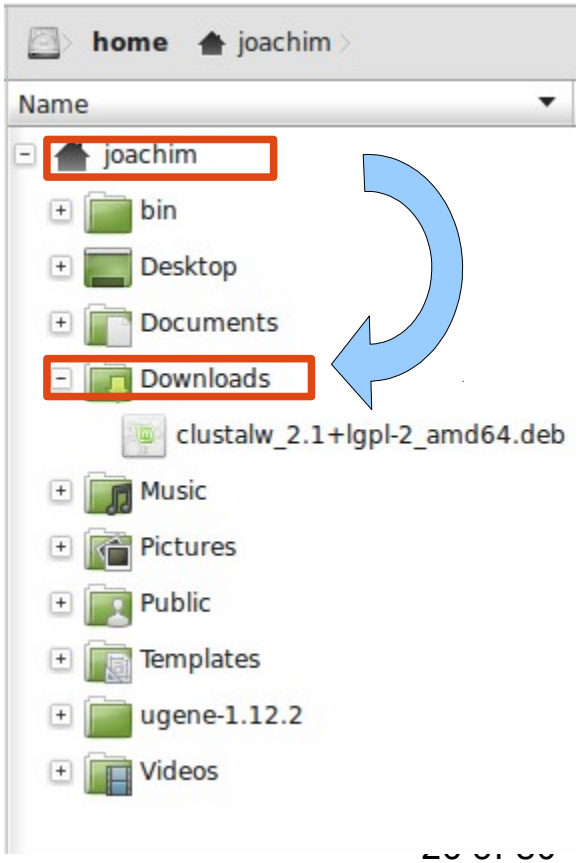


What will happen if we type 'ls' now?

Navigating in the file system

The result is that the prompt has changed position from:





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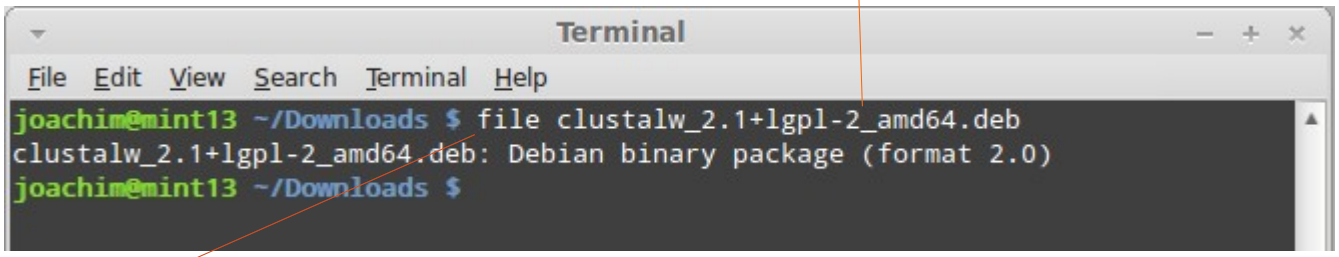
Running a command on a file

We can provide a file name as an **argument** to a command. In the Downloads directory, we can for example check a file type with the command **file**.

Argument points to a file



file = is a command, itshows the file type of the file passed as argument

You never walk alone

How to know the commands, and which arguments they need?

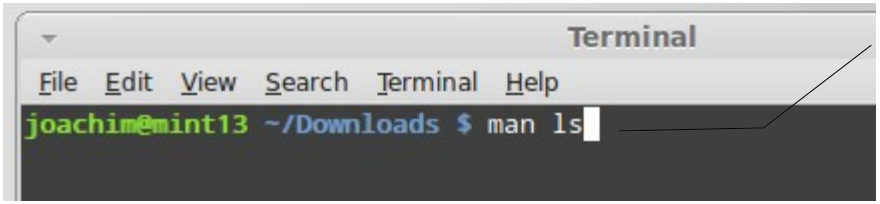
A Linux system comes with batteries included: only they are called **man-pages** (manual).

The program **man** displays the manual for the program provided as argument.

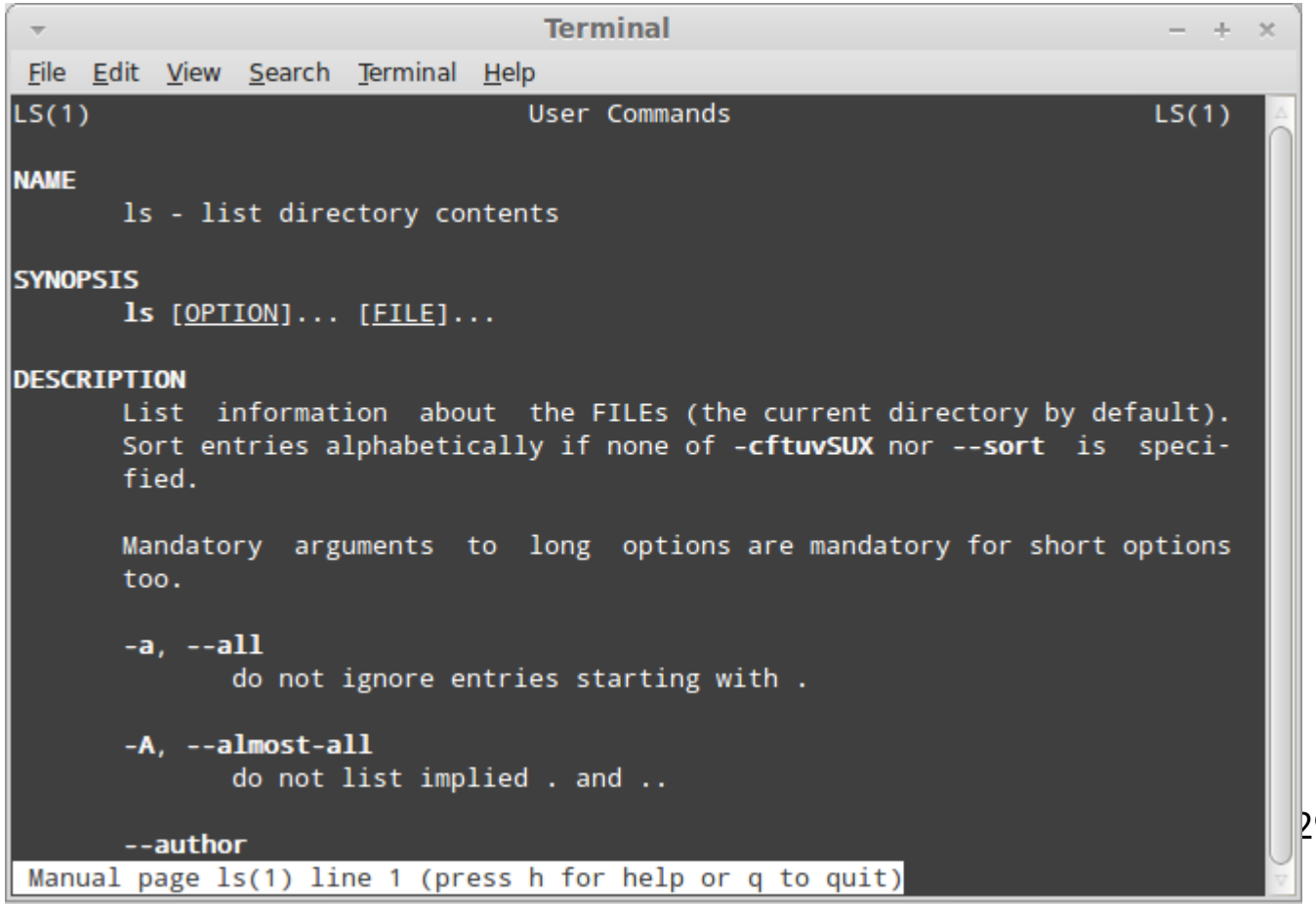
For example: the manual of **ls**.

http://www.thegeekstuff.com/2013/09/man-command/

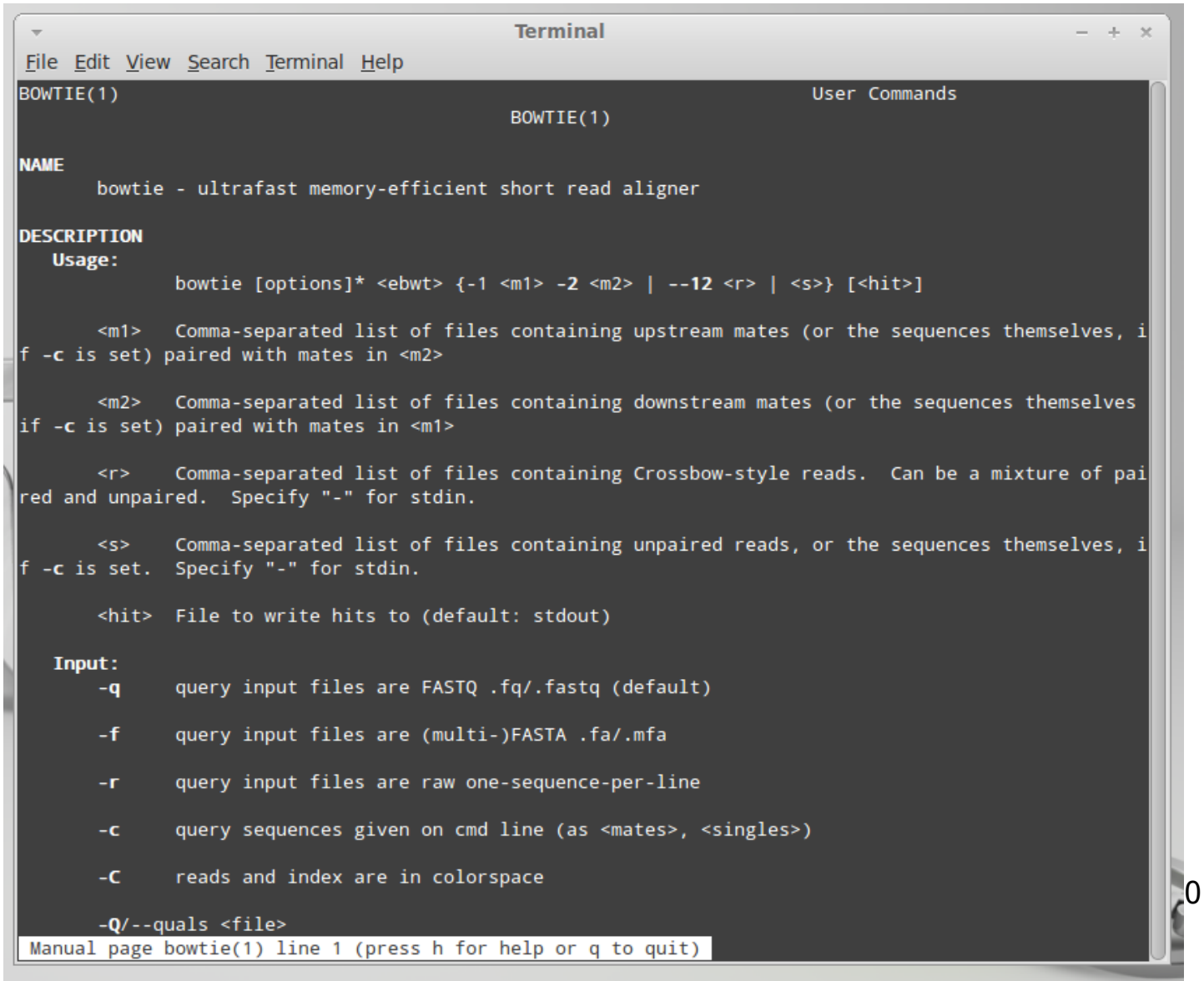
You never walk alone



Execute the program 'man' with argument 'ls', meaning: show me the manual of ls



E.g. Bowtie has also a manual



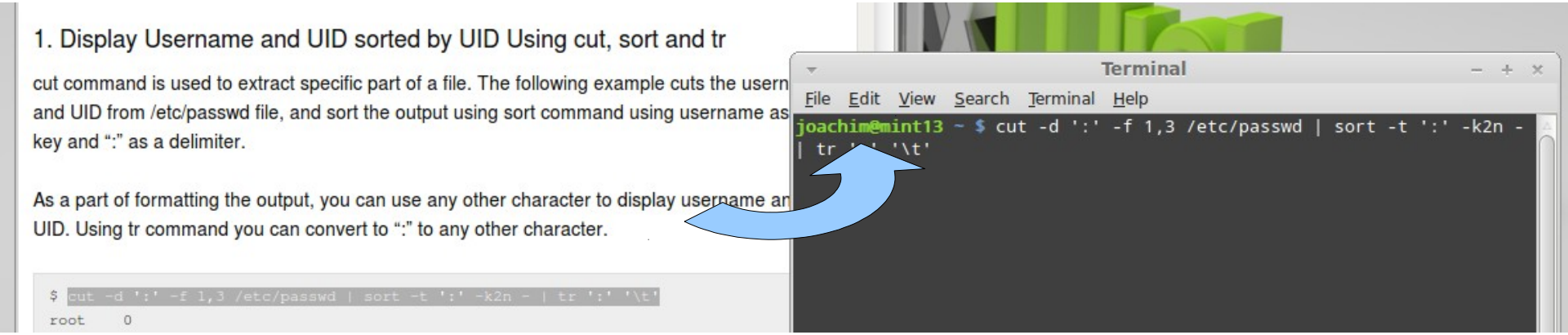
Usage tips for the program man

↑ and ↓	scroll up and down
PgUp	previous page
PgDown or space	next page
< and >	begin and end of the text file
/	search (forward)
n	next search hit
q	to exit

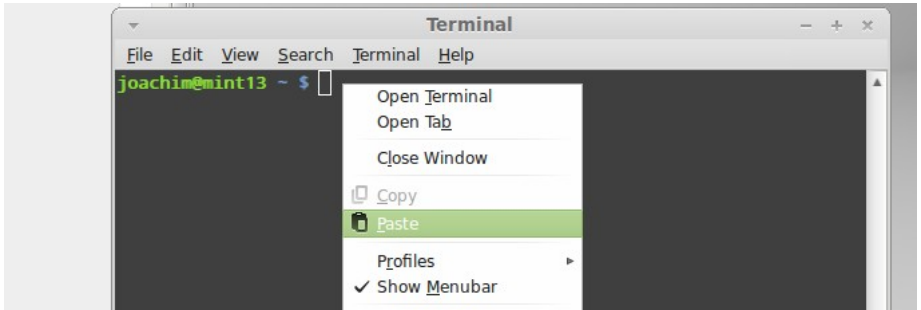
(The command man uses less under the hood to display the manual page.)

Using the terminal: copy/pasting

- Normal copy/paste: hold shift + ctrl + c / v
- Select text somewhere (e.g. in browser), and **click with the scroll wheel** in your terminal.



- Copy and paste by right-clicking and selecting from the menu



Fine-tuning commands behaviour

- Reading man pages you can find how to use the **arguments and options.**
- Setting these influences the way commands behave. **Options** precede arguments, and are separated from the command (and from each other) by **spaces**. They usually start with '-' or '--'.
- For example:

From now on this will be the notation for command line instructions as a normal user

```
$ ls -l /bin
```

Program (first thing you type should always be a program)

Option: you want 'ls' to change default behaviour: -l adds more info ('long').

Argument: on what content (file, directory,...) should ls operate.

Help! The most used option

Another way to get help, besides the man pages, is to invoke the option '**--help**'. Nearly every command has this option.

```
joachim@joachim-VirtualBox ~ $ ls --help
Usage: ls [OPTION]... [FILE]...
List information about the FILEs (the current directory by default).
Sort entries alphabetically if none of -cftuvSUX nor --sort is specified.

Mandatory arguments to long options are mandatory for short options too.
  -a, --all                  do not ignore entries starting with .
  -A, --almost-all           do not list implied . and ..
      --author               with -l, print the author of each file
  -b, --escape               print C-style escapes for nongraphic characters
      --block-size=SIZE      scale sizes by SIZE before printing them.  E.g.,
                               `--block-size=M' prints sizes in units of
                               1,048,576 bytes.  See SIZE format below.
  -B, --ignore-backups       do not list implied entries ending with ~
  -c                         with -lt: sort by, and show, ctime (time of last
                               modification of file status information)
                               with -l: show ctime and sort by name
                               otherwise: sort by ctime, newest first
```

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Short and long options

Some options have two names: a short and a long name. **Short** are one character long, and start with a '-'. **Long** options are usually a word, and are preceded by '--'.

```
joachim@joachim-VirtualBox ~ $ ls --help
Usage: ls [OPTION]... [FILE]...
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  -c                         with -lt: sort by, and show, ctime (time of last
                               modification of file status information)
                               with -l: show ctime and sort by name
                               otherwise: sort by ctime, newest first
```

Short options peculiarities

- You can add multiple options to the command. (the given order is seldom important)

```
$ ls -l -t /bin
$ ls -t -l /bin
```

- Using short options allow you to **combine** several options in one string.

```
$ ls -r -l -t
$ ls -rtl
```

Long options

- 'Long' options consist of -- (two dashes) followed by the name of the option (string):
  ```
  $ ls --recursive
  ```
- Long options **cannot be combined** like their 'short' counterparts

Options can also have arguments

- For example, show the contents of the directory, sorted by size of the files.
- We use the option --sort for this: the argument to sort must follow the option:

```
$ ls --sort=size /bin
```

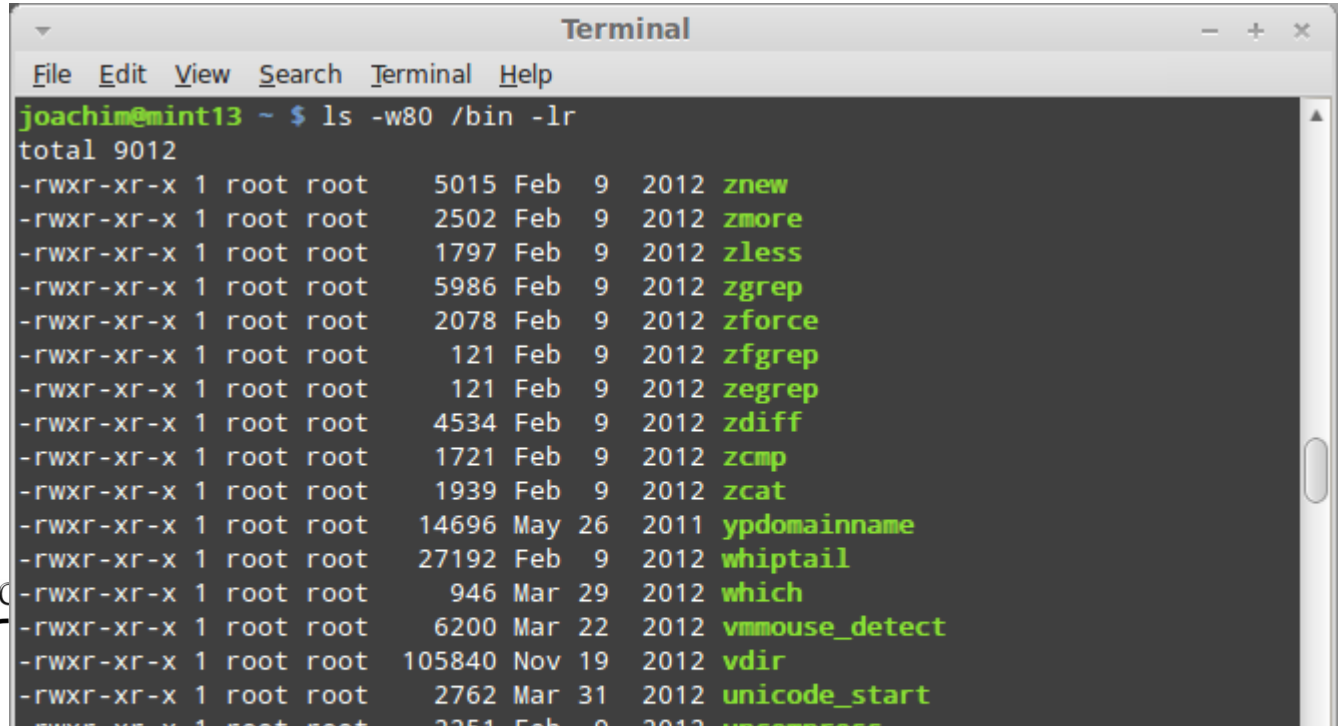
  - the '=' sign is optional
- An example of an argument to a short option:

```
$ ls -w 80 /bin
```

  - the space between option name and argument is optional

Different combinations of options

```
$ ls -lr -w 80 /bin
$ ls -rlw 80 /bin
$ ls -wrl 80 /bin    # NOK
$ ls -w80 /bin -lr
```



Some basic commands

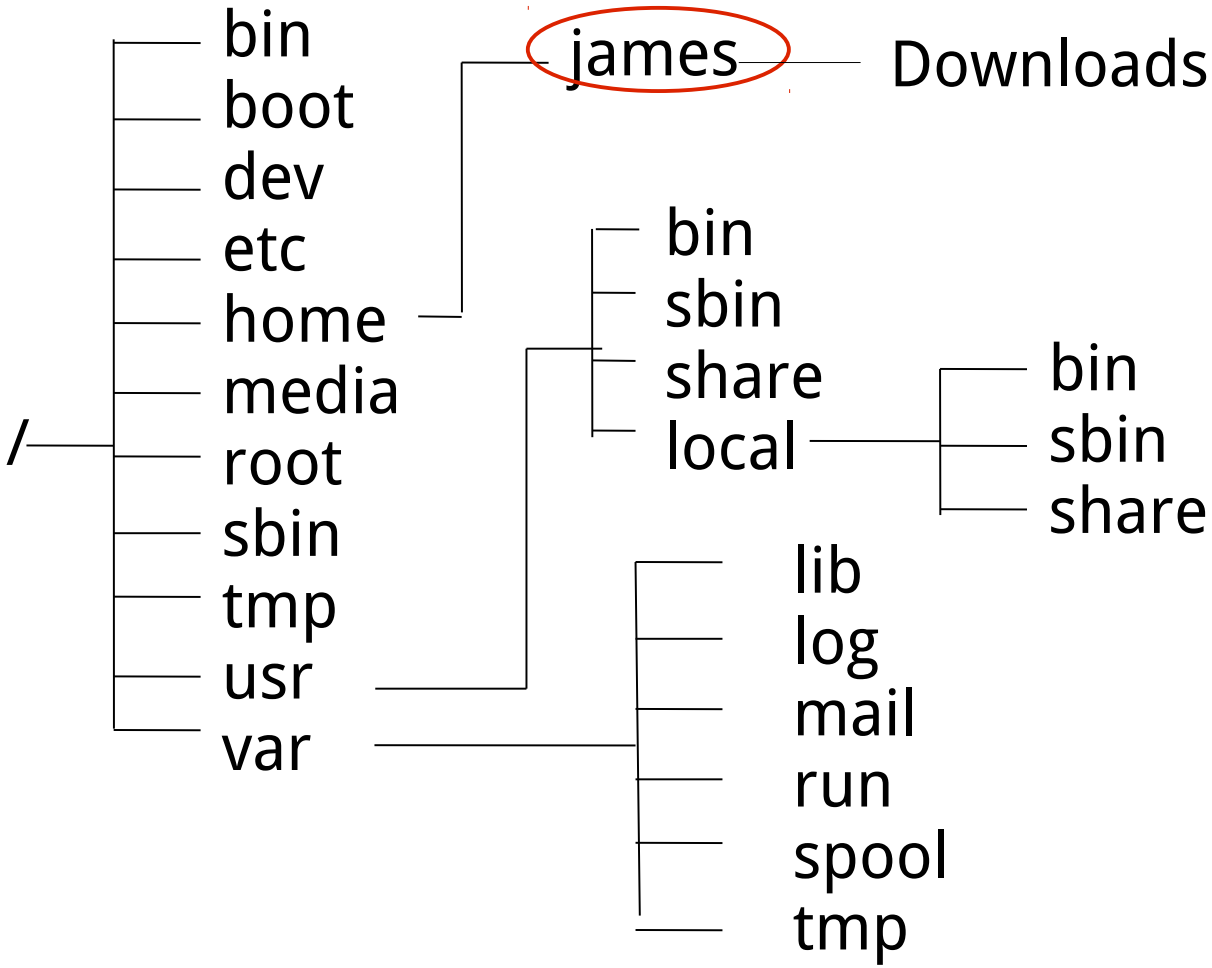
Command	Explanation
pwd	Print working directory
ls	Print content of directory
cd	Change directory
cat	Print the contents of a file
cp	Copy a file
mv	Move a file
rm	Remove a file
less	Read the contents of a file
clear	Clear the terminal screen
head	Show the first 10 lines of a file
tail	Show the last 10 lines of a file
nano	Text editor, to modify text files
wget	Download a file from an URL

http://wiki.bits.vib.be/index.php/Linux_Beginner%27s_Cheat_page

Exercise: gentle intro to the command line

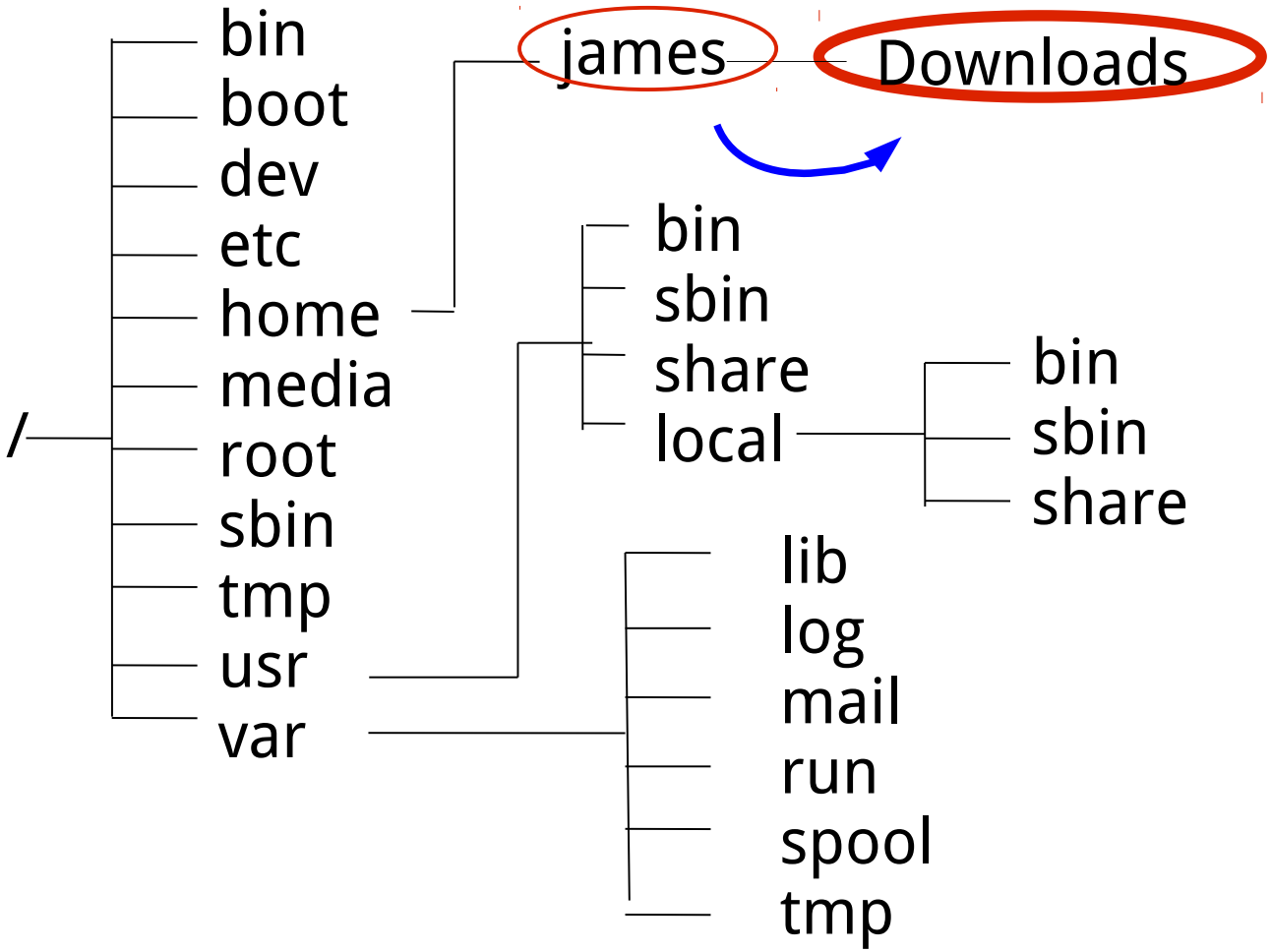
→ Exercise link

Paths and the working directory



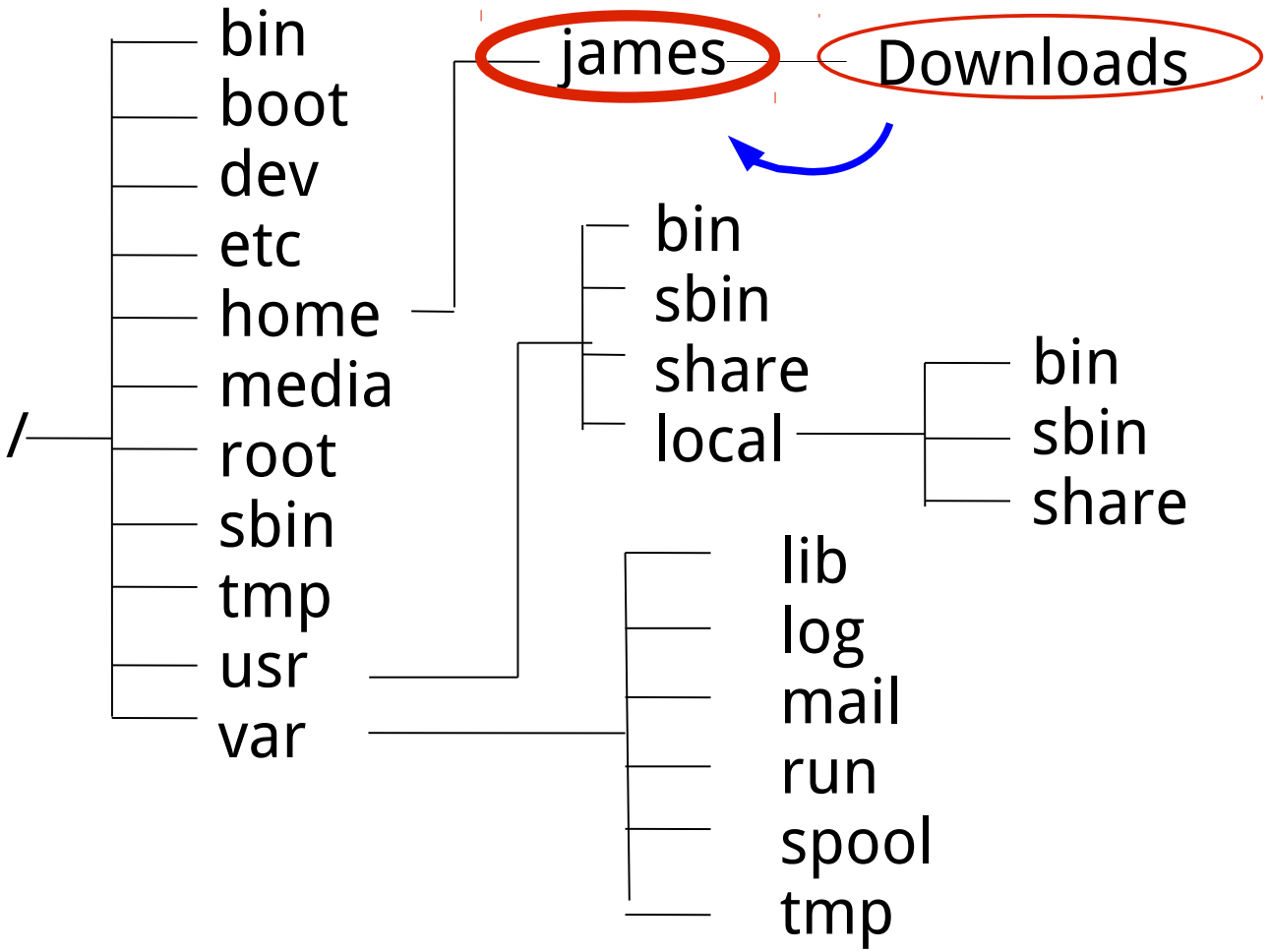
Paths and the working directory

```
~ $ cd Downloads
```



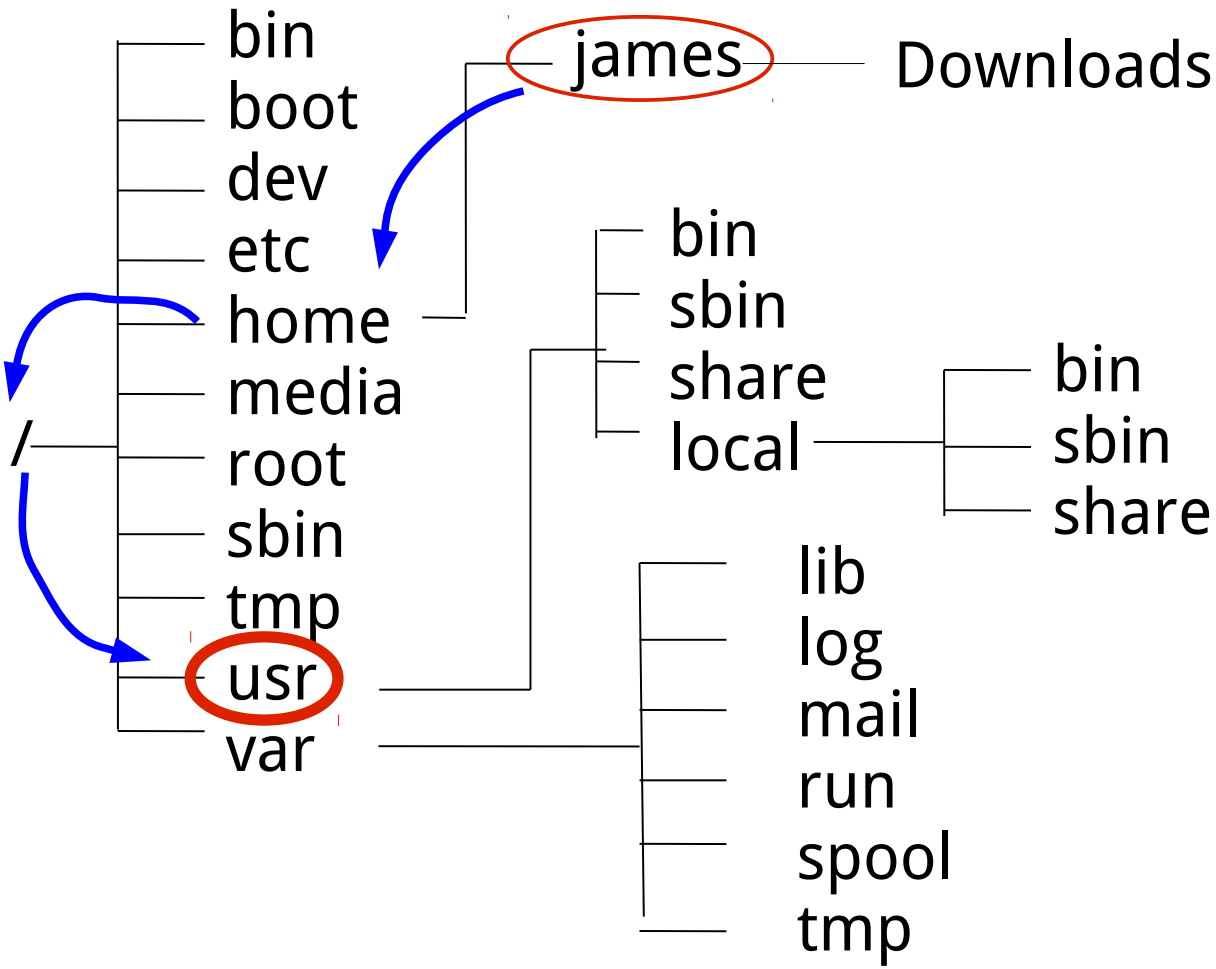
Paths and the working directory

```
~/Downloads $ cd ..
```



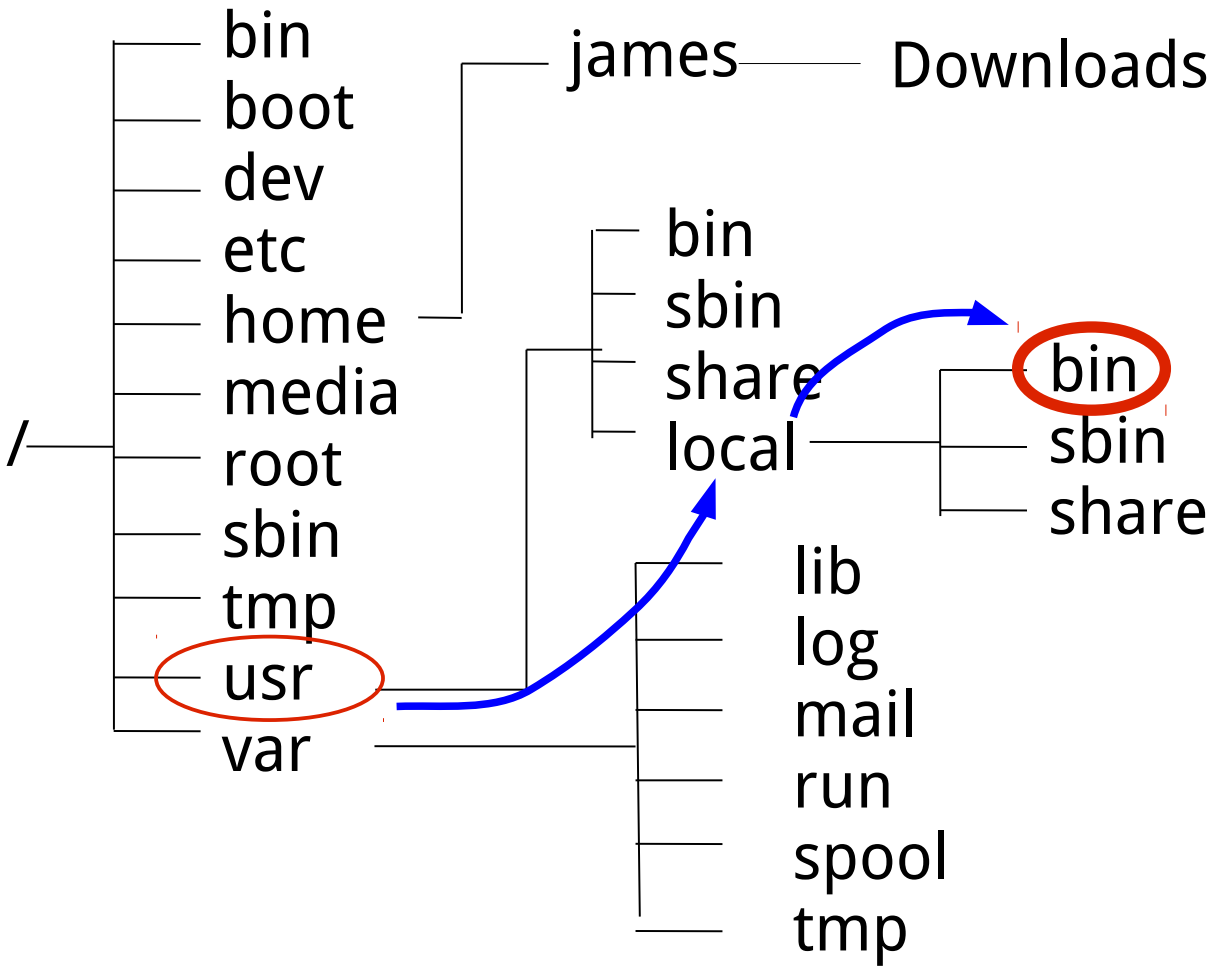
Paths and the working directory

```
~ $ cd ../../usr
```



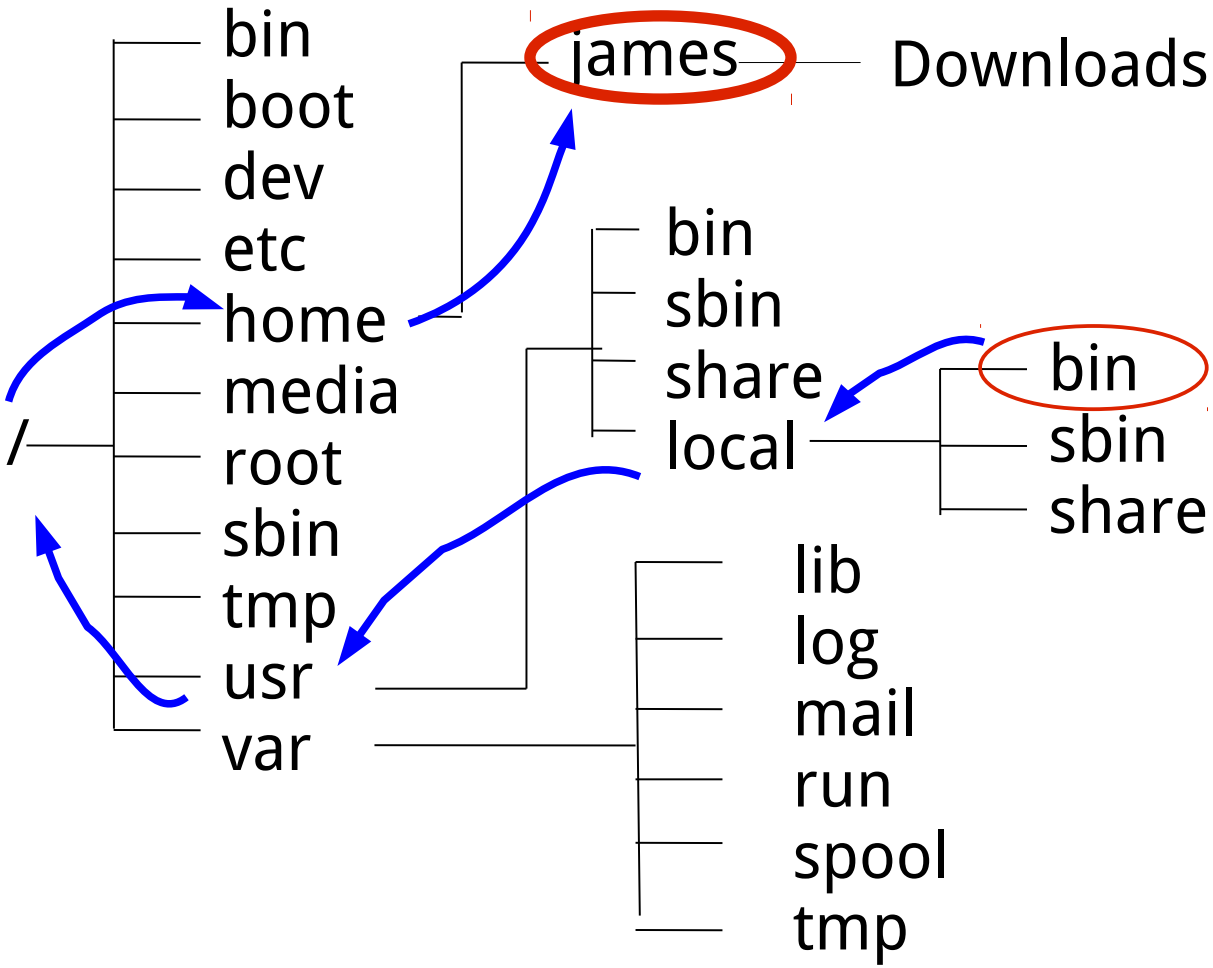
Paths and the working directory

```
/usr $ cd local/bin
```



Paths and the working directory

```
/usr/local/bin $ cd ../../../home/james
```



Relative paths

The **path** is set up **relative to the current working directory**.

In other words: which steps do we take from the current directory to reach the destination.

```
/usr/local/bin $ cd ../../../home/james
```

```
/usr $ cd local/bin
```

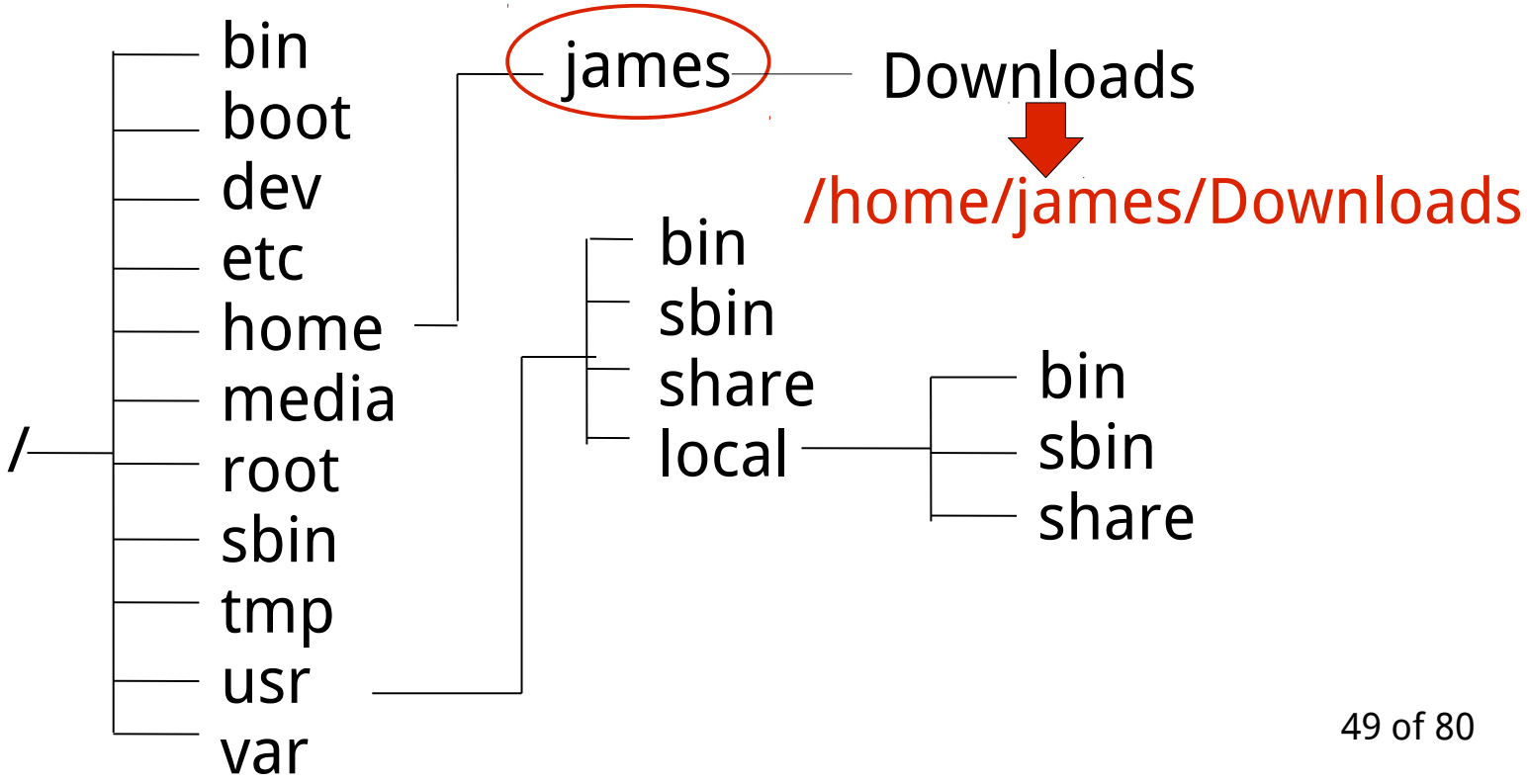
```
~ $ cd ../../usr
```

```
~ $ cd Downloads
```

```
~/Downloads $ cd ..
```

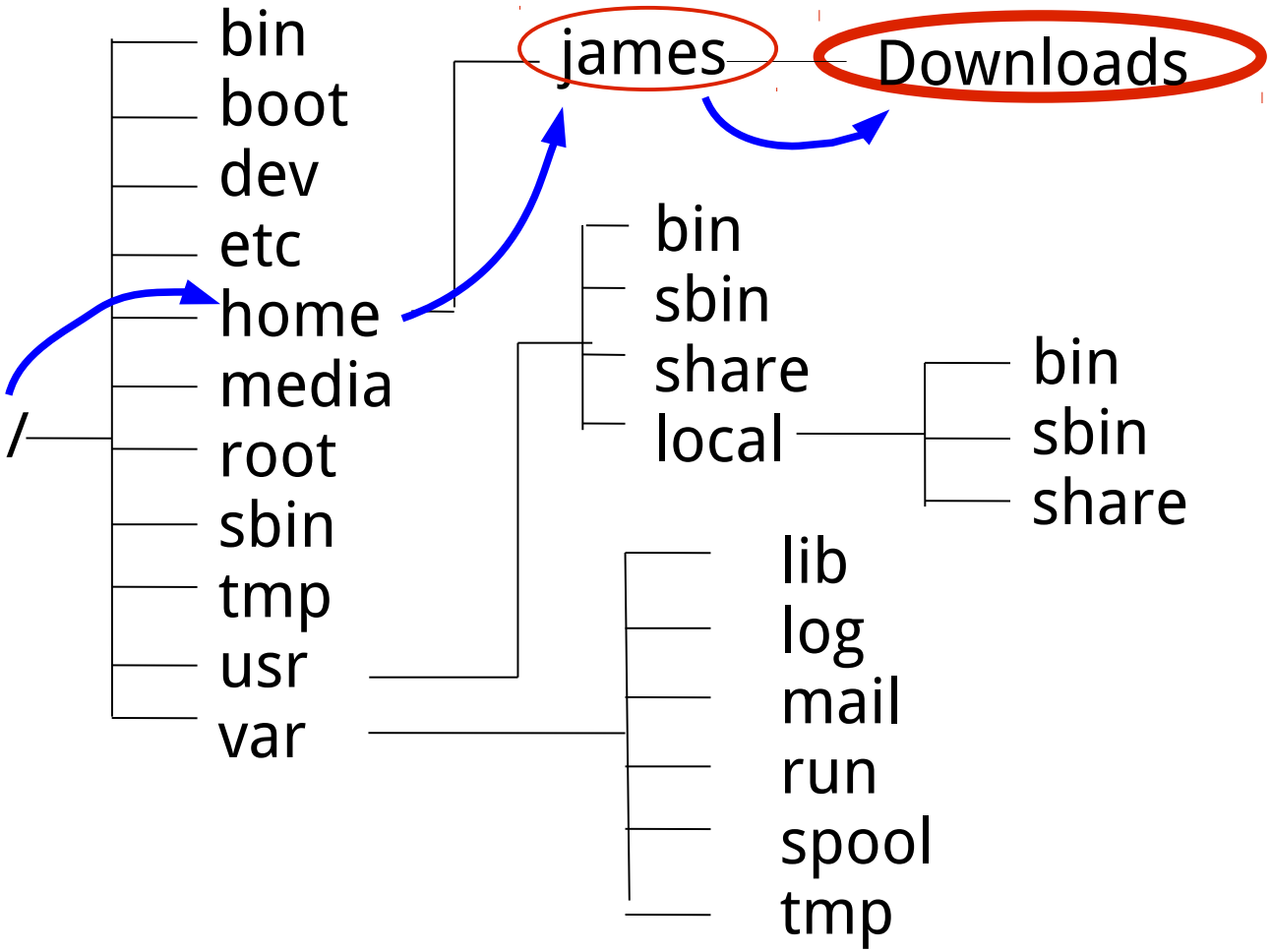
Absolute paths

Sometimes it is more convenient to point to the complete or **absolute** path of the directory, starting from the **root directory.**



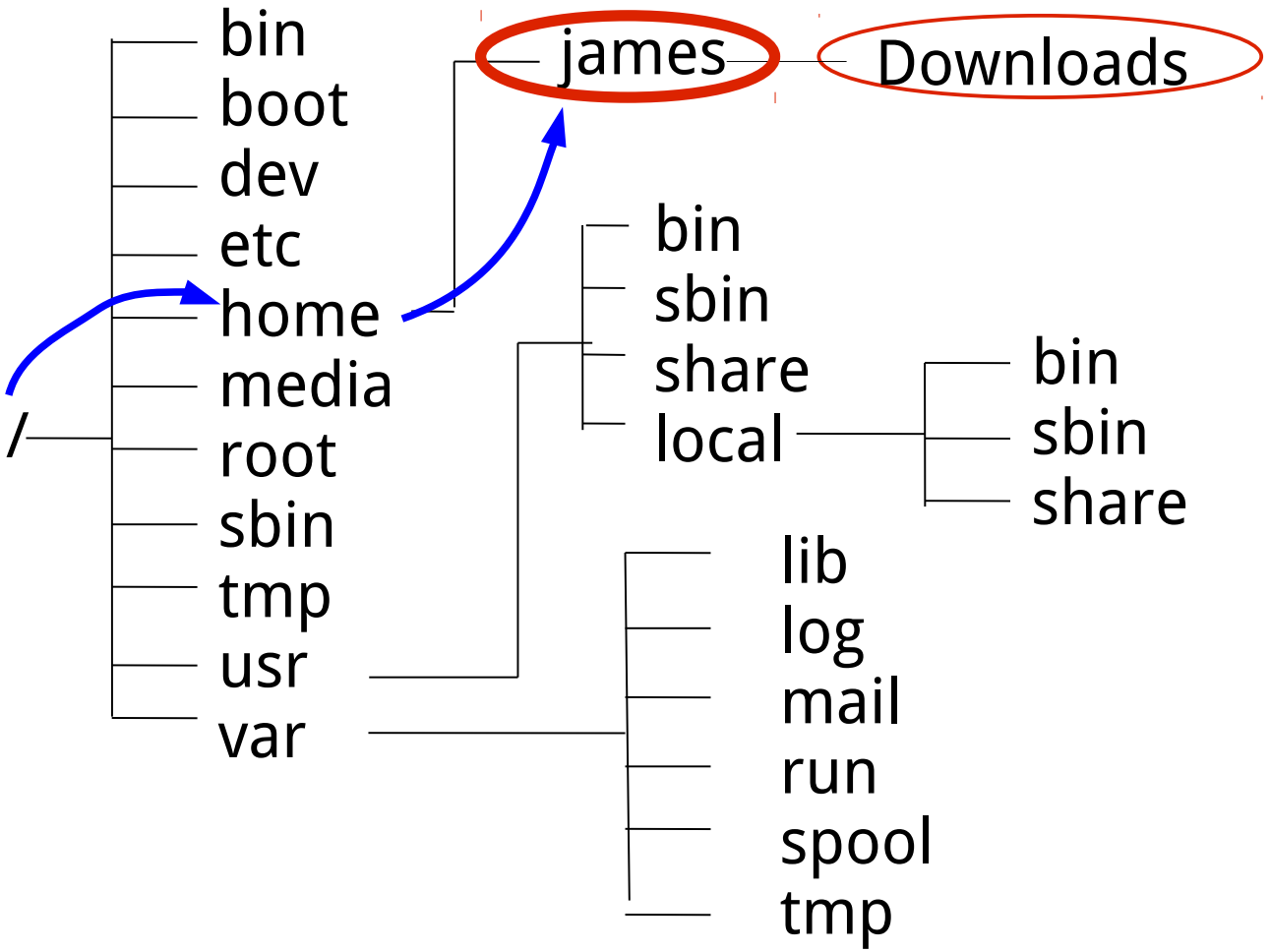
Paths and the working directory

```
~ $ cd /home/james/Downloads
```



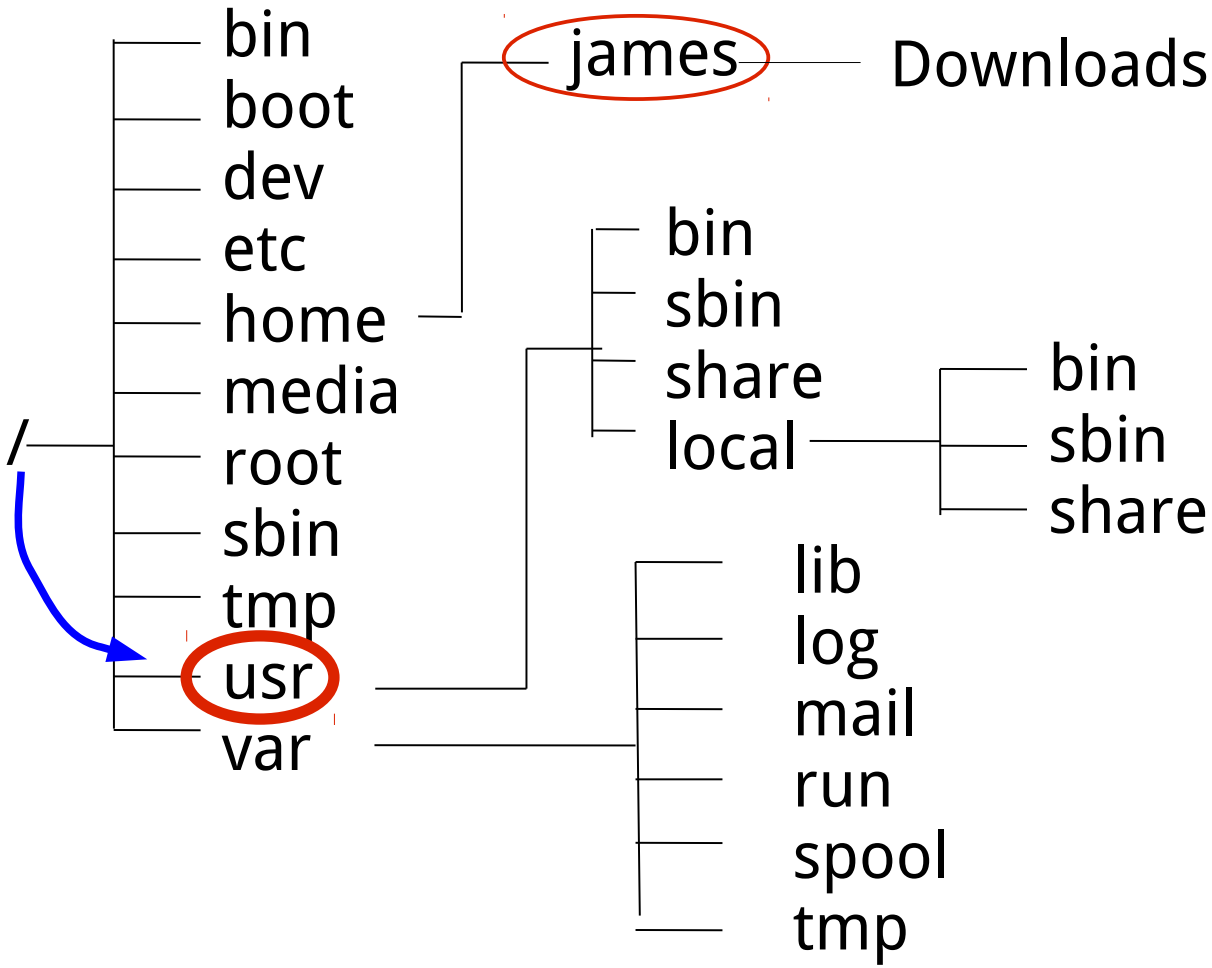
Paths and the working directory

```
~/Downloads $ cd /home/james
```



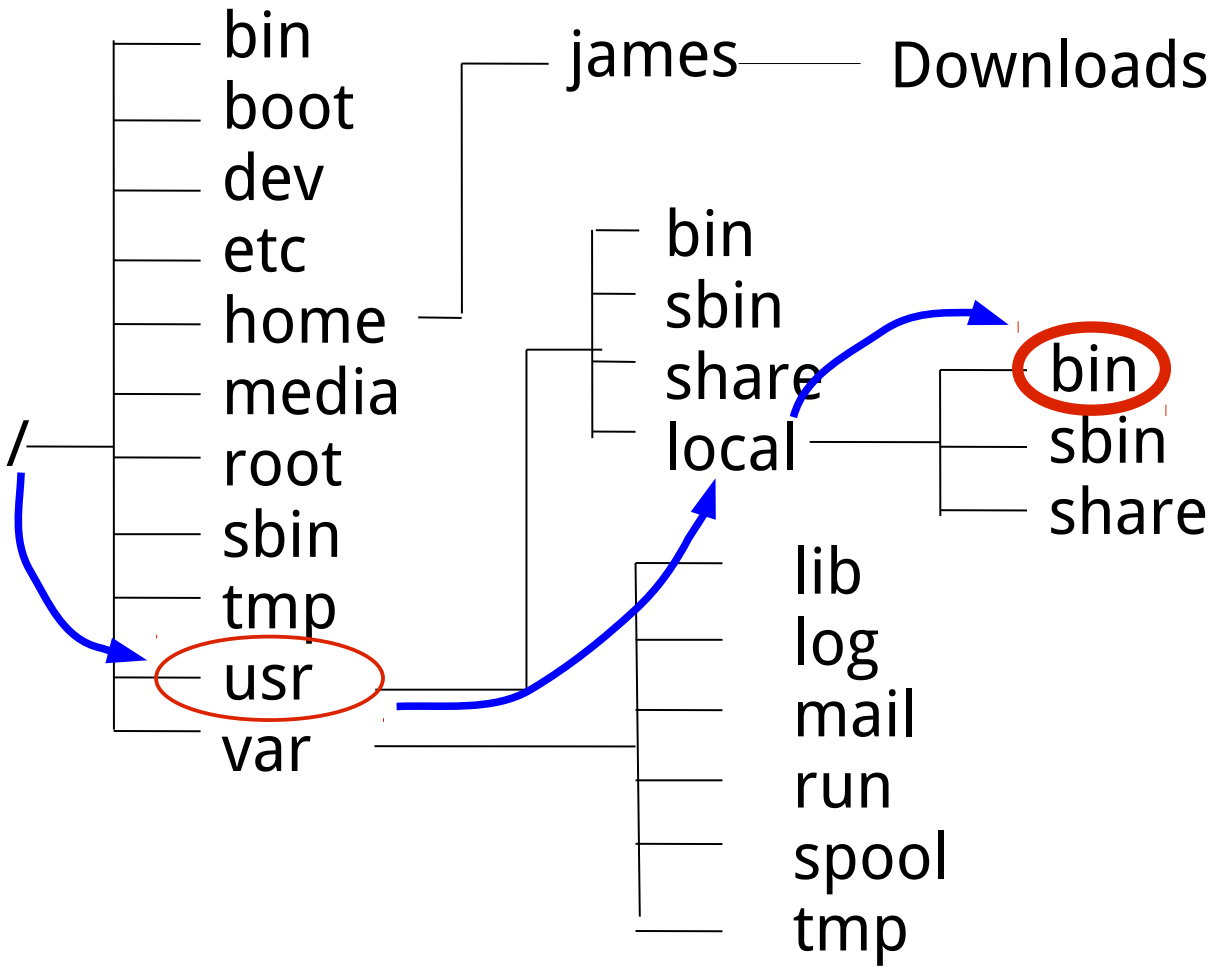
Paths and the working directory

```
~ $ cd /usr
```



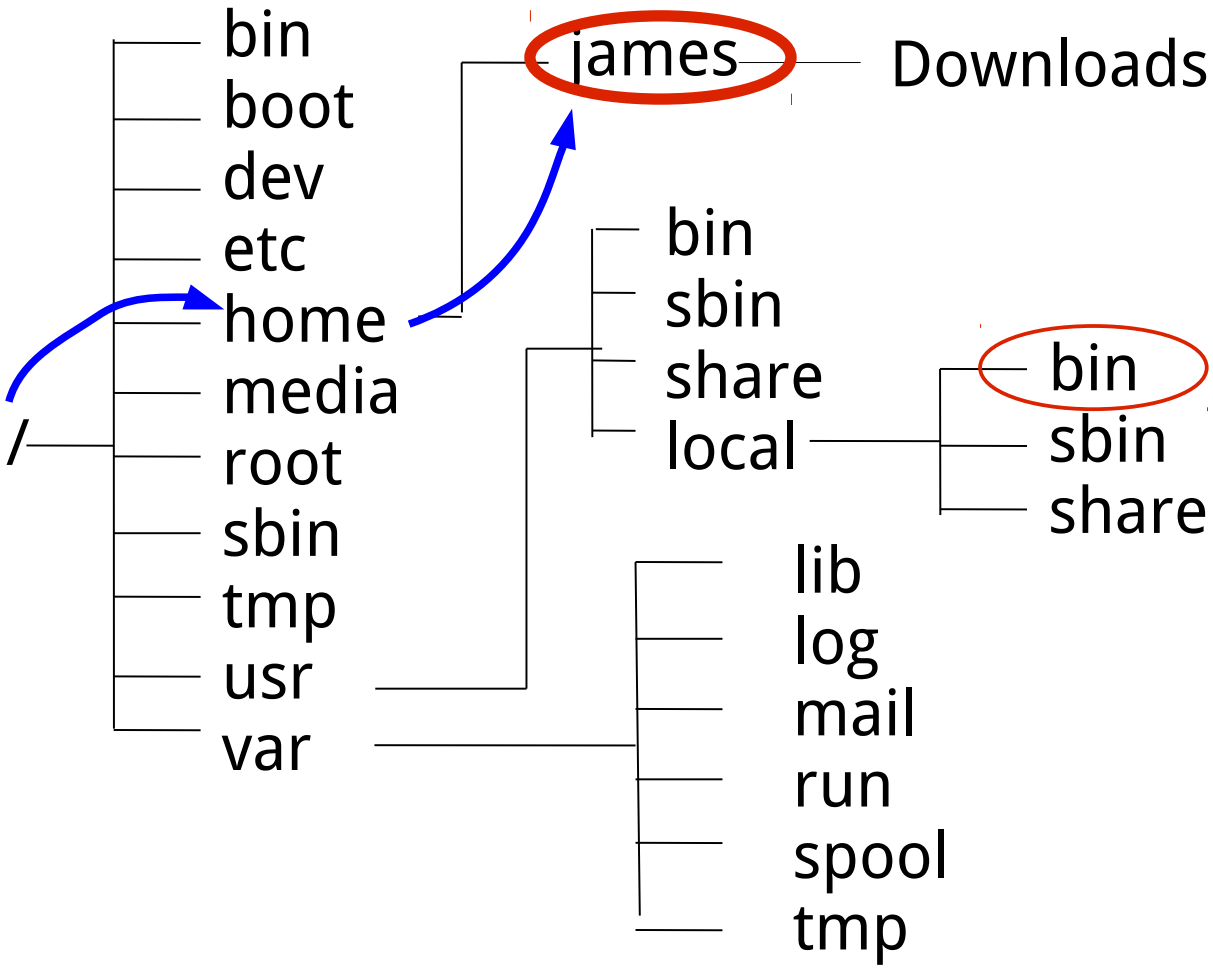
Paths and the working directory

```
/usr $ cd /usr/local/bin
```



Paths and the working directory

```
/usr/local/bin $ cd /home/james
```



Relative versus absolute paths

Relative ↔ absolute (=starts always with /, the root)

```
/usr/local/bin $ cd ../../../home/james
```

```
/usr/local/bin $ cd /home/james
```

```
/usr $ cd local/bin
```

```
/usr $ cd /usr/local/bin
```

```
~ $ cd ../../usr
```

```
~ $ cd /usr
```

```
~ $ cd Downloads
```

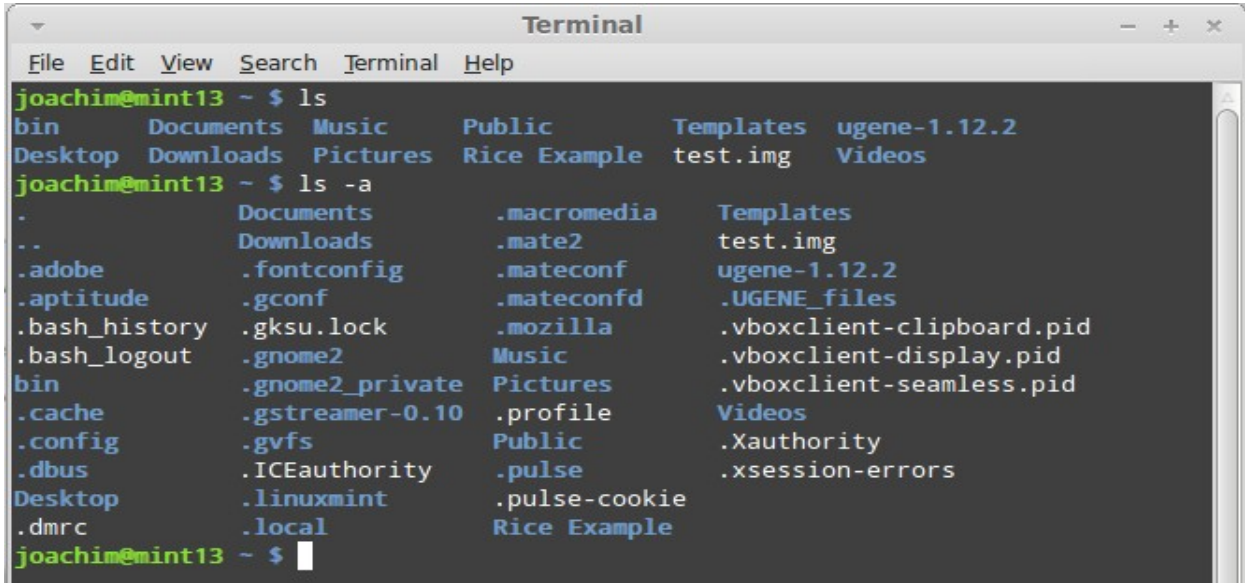
```
~ $ cd /home/james/Downloads
```

```
~/Downloads $ cd ..
```

```
~/Downloads $ cd /home/james
```

Hidden directories

- Compare the output of `ls` versus `ls -a`



- Check with the file manager your home.
- **Hidden** files and folders start with '.'. They are not shown by default.

Moving data around

- Copy files:

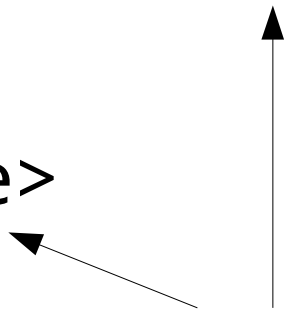
  ```
  $ cp <what> <to where>
  ```

- Move files:

  ```
  $ mv <what> <to where>
  ```

- Remove files:

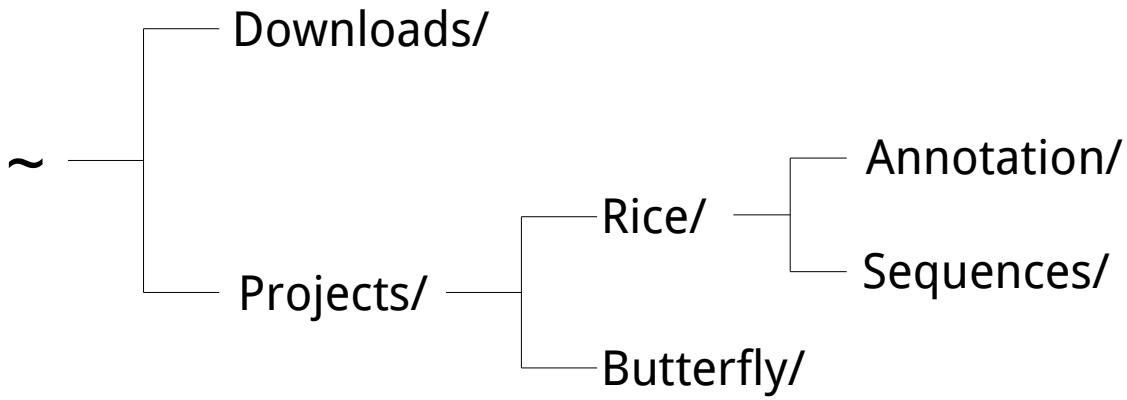
  ```
  $ rm <filename>
  ```



Absolute or relative paths to the files

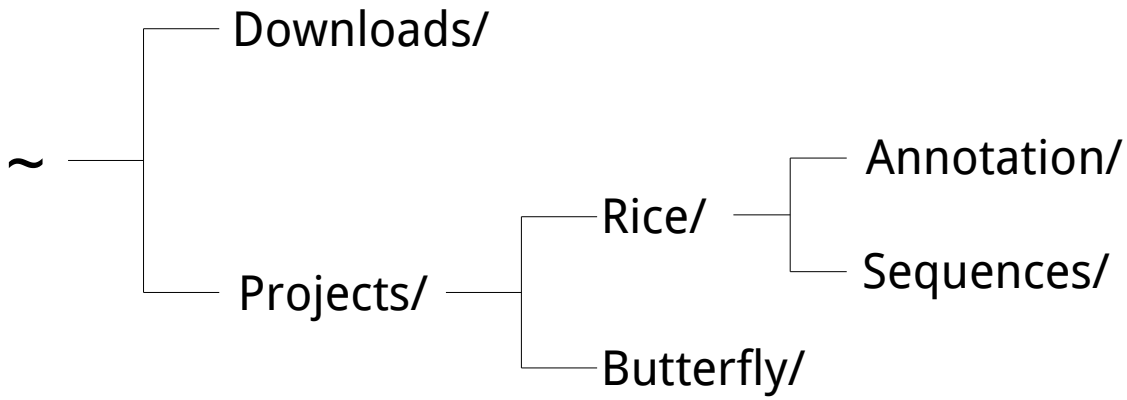
Moving data around

If we have following directory structure...

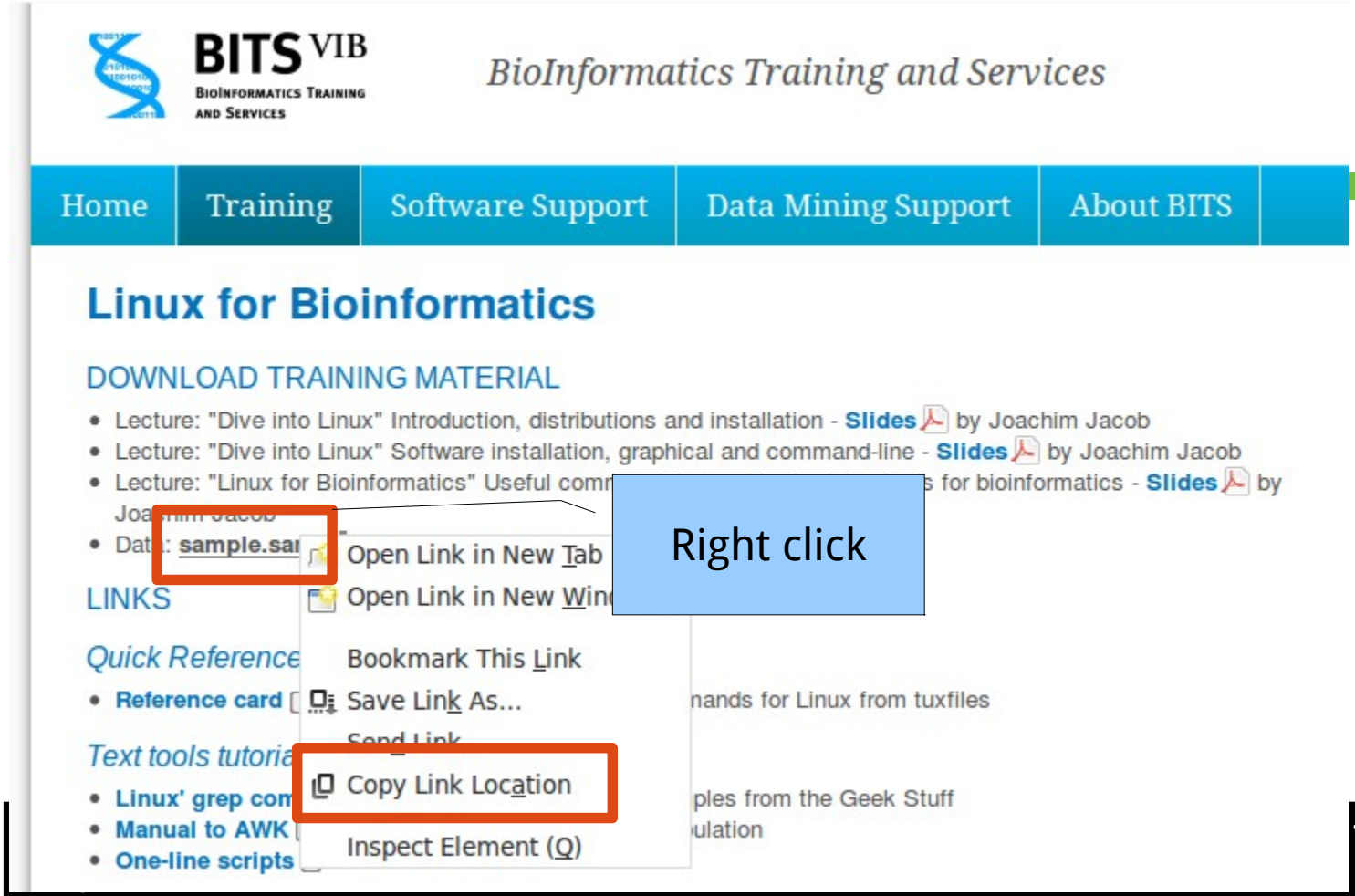


Moving data around

If we have following directory structure...




```
~ $ mkdir -p Projects/{Rice/{Annotation,Sequences},Butterfly}
~ $ cd ~/Downloads
~ $
```

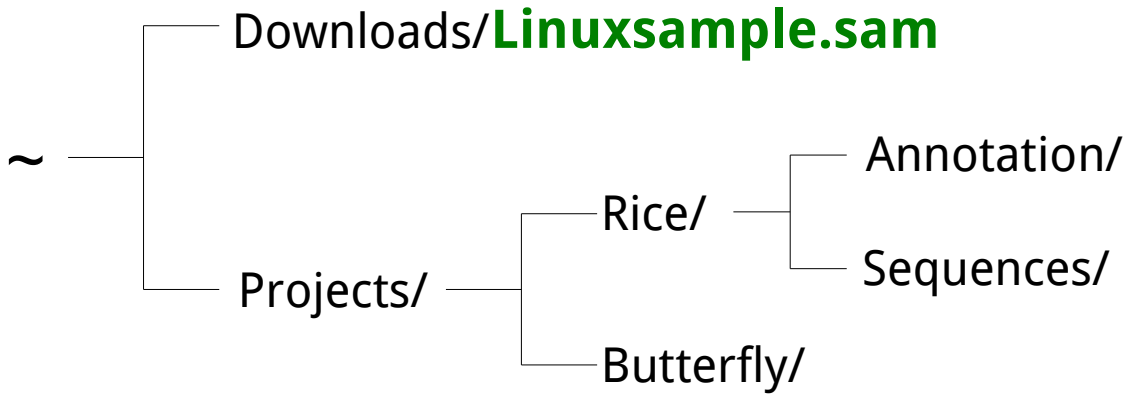



```
tterfly}

~ $ wget http://dl.dropbox.com/u/58174806/Linuxsample.sam
```

Moving data around

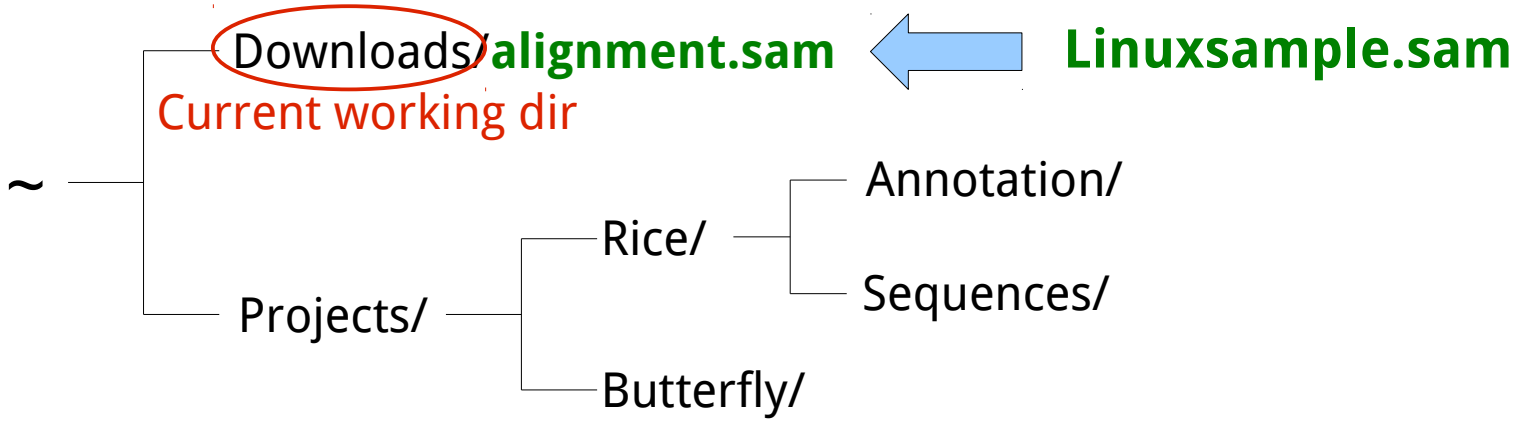
If we have following directory structure...




```
~ $ mkdir -p Projects/{Rice/{Annotation,Sequences},Butterfly}
~ $ cd ~/Downloads
~ $ wget http://dl.dropbox.com/u/58174806/Linuxsample.sam
```

Moving data around

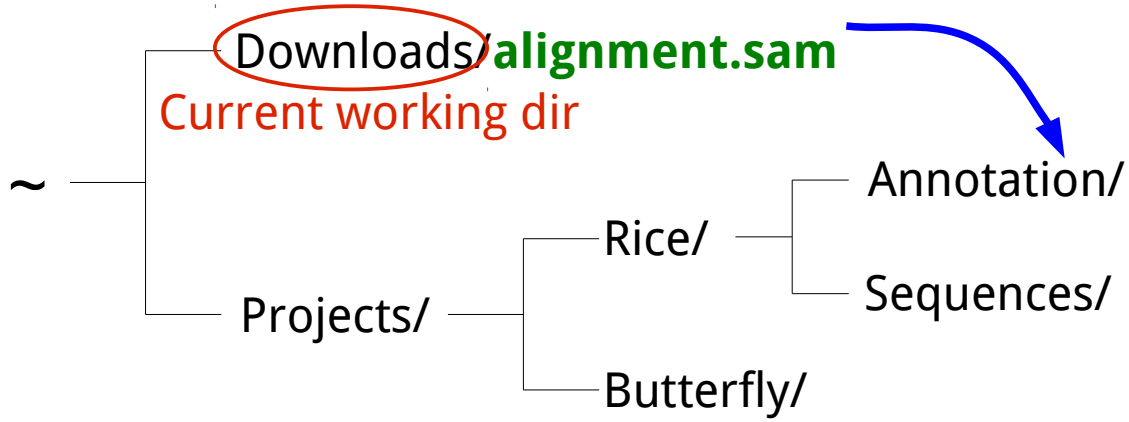
Rename the downloaded Linuxsample.sam




```
~/Downloads $ pwd
/home/joachim/Downloads
~/Downloads $ ls
Linuxsample.sam
~/Downloads $
```

Moving data around

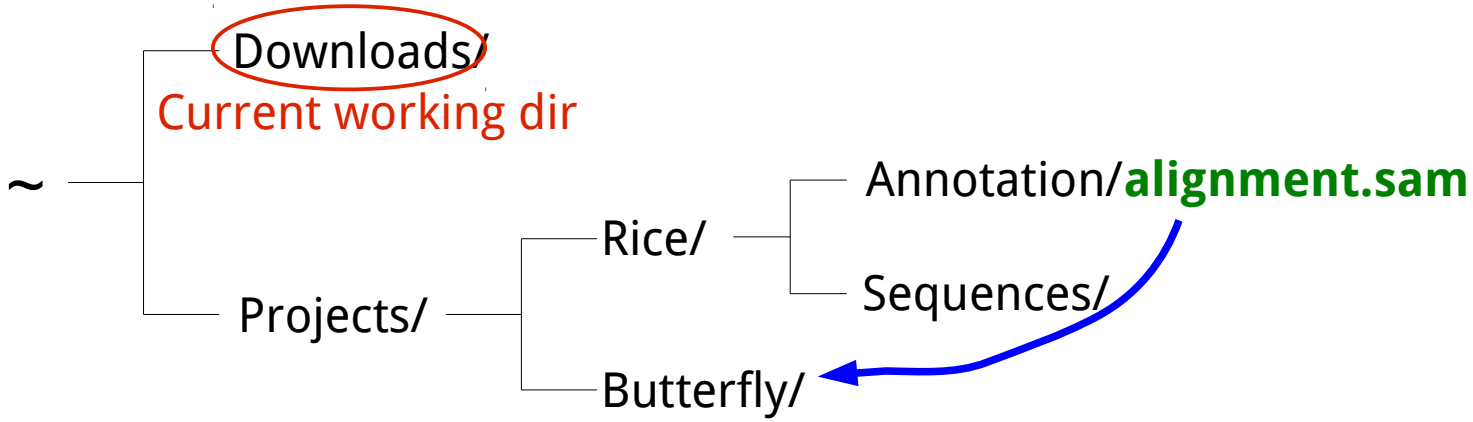
Move the sam file




```
~/Downloads $
```

Moving data around

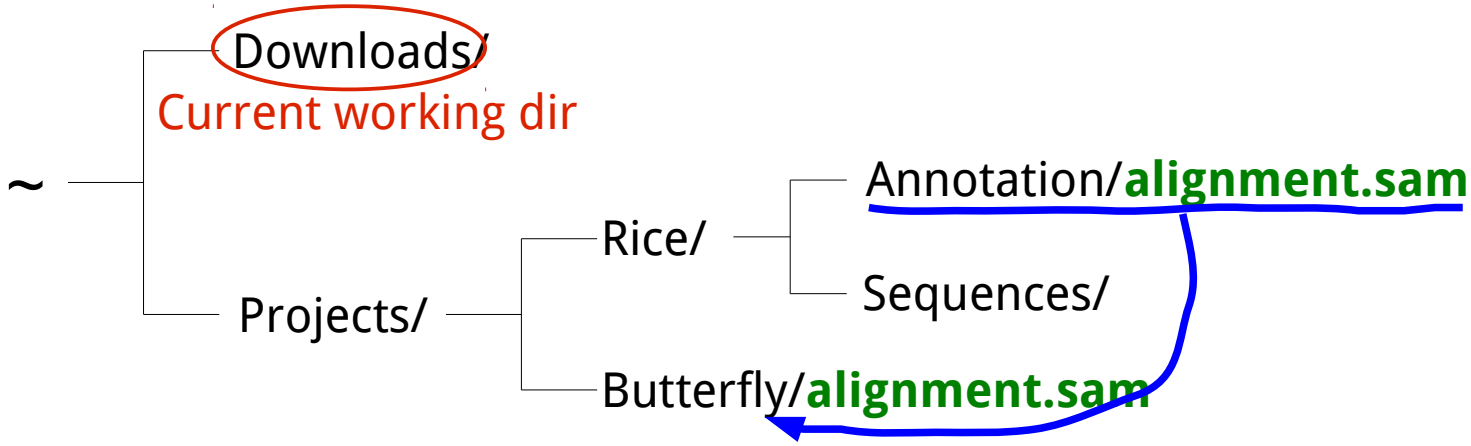
Copy the sam file




```
~/Downloads $ cp                                    \
```

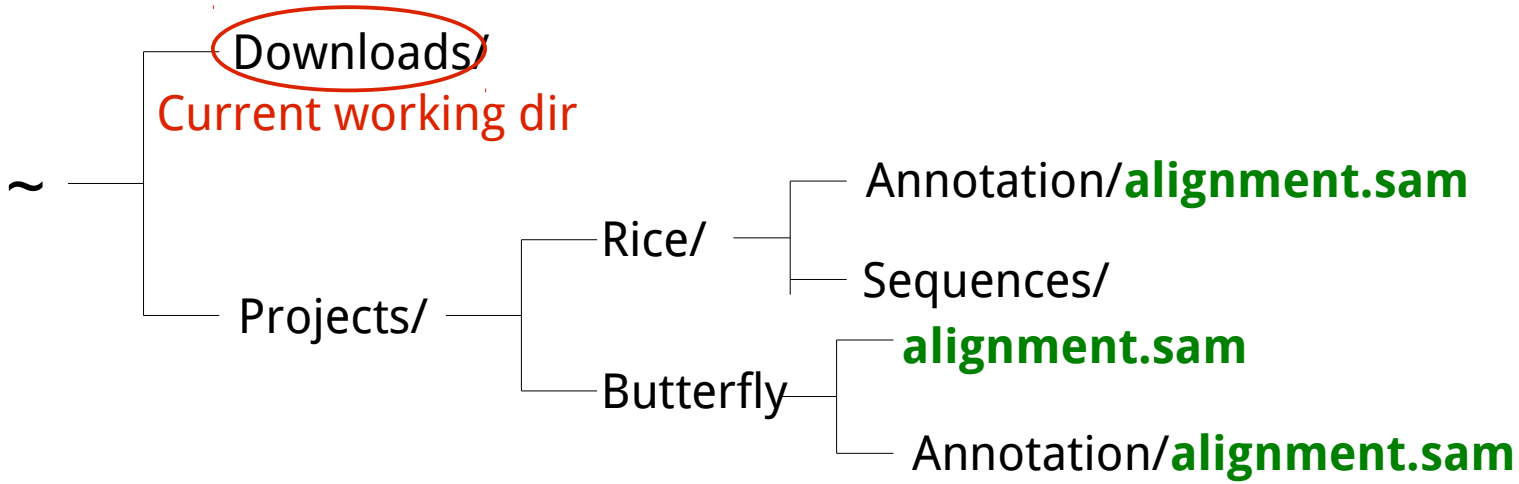
Moving data around

Copy the complete directory



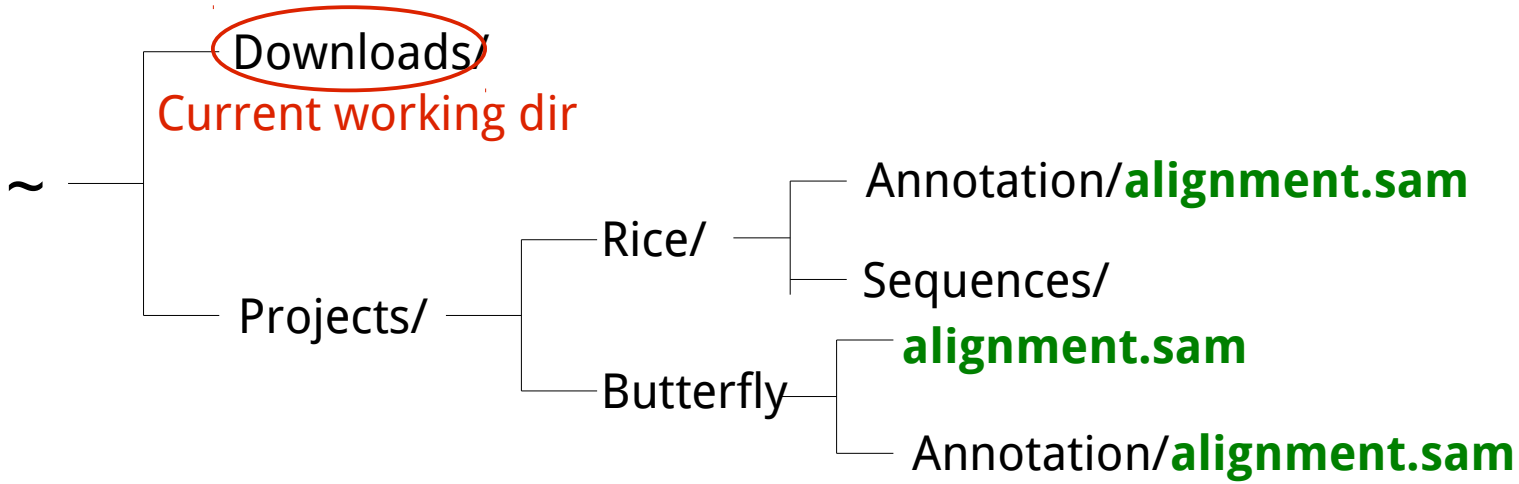

```
~/Downloads $ c
```

Reading files



What kind of file is .sam?

Reading files



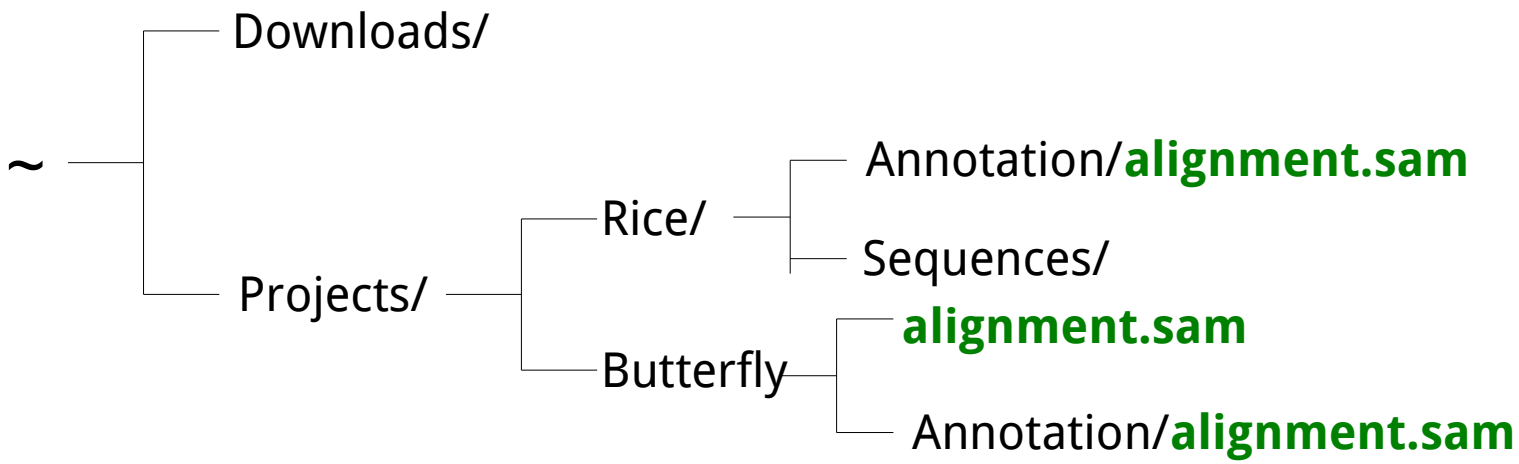
$ **cat** : display the content of the file **at once**

$ **less** : display the content **page by page**

$ **nano** : **edit** the content of the file

Reading files

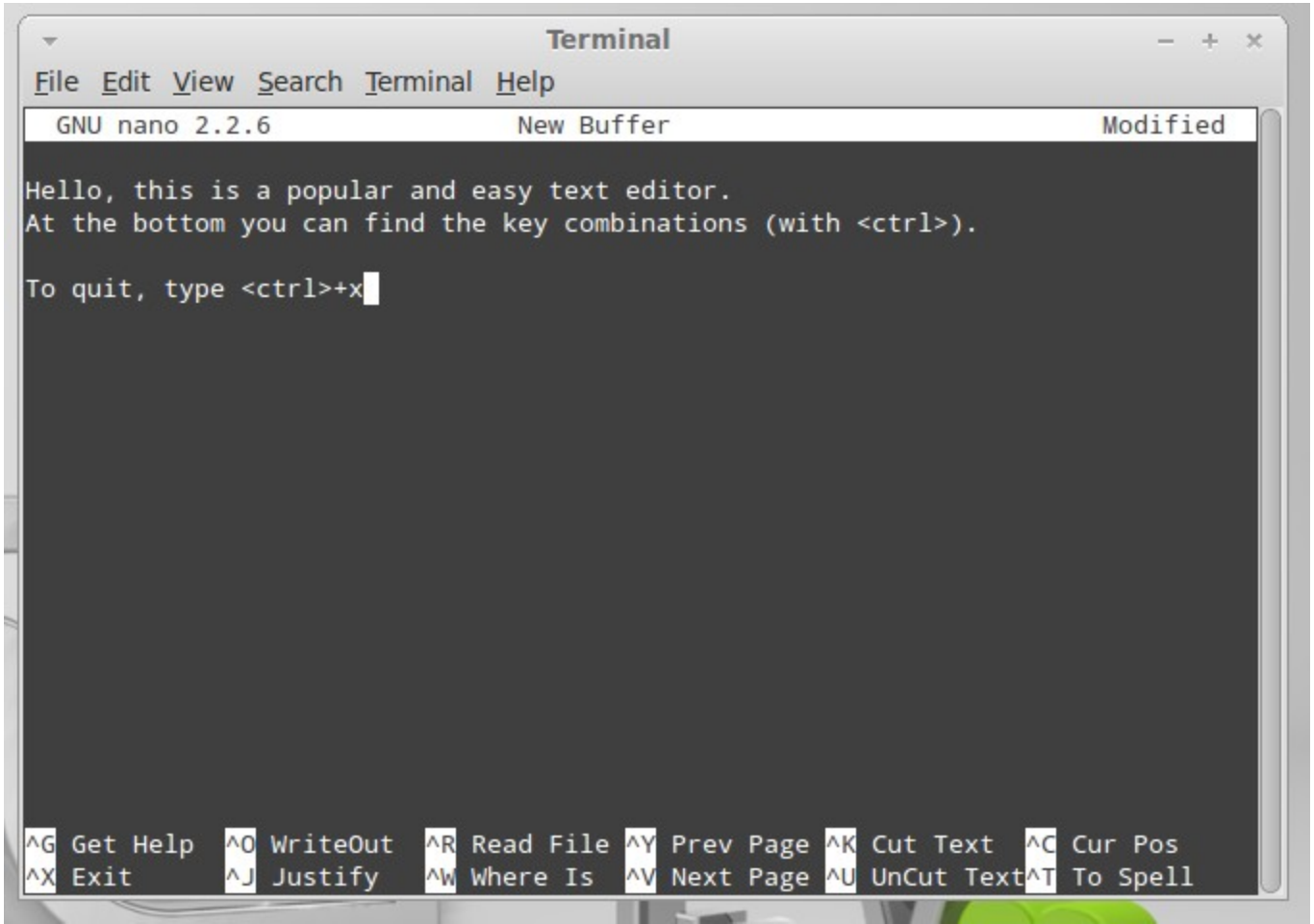
Try the 3 commands below




```
~/Projects/Butterfly $ cat alignment.sam
~/Projects/Butterfly $ less alignment.sam
~/Projects/Butterfly $ nano alignment.sam
```

Editing files

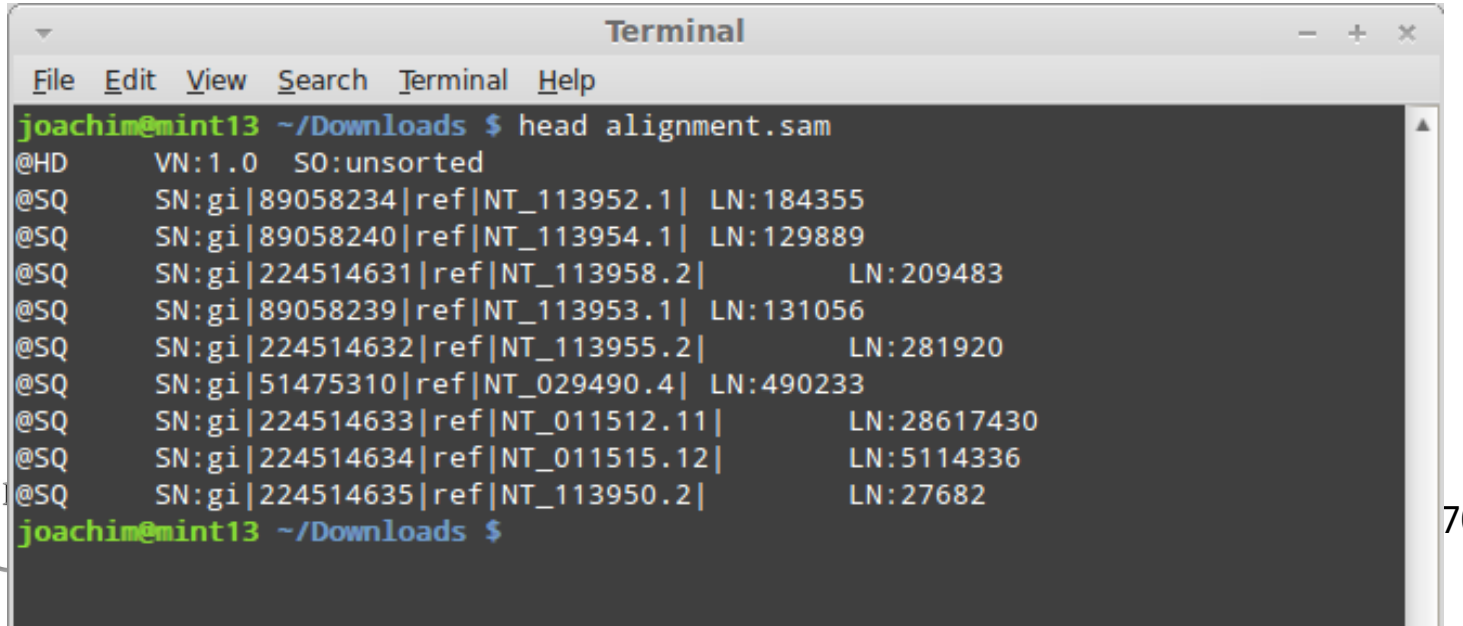
nano is a popular text editor to edit files.



Reading files

Display first or last lines of a text file, with **head** or **tail**.

```
~/Projects/Butterfly $ head alignment.sam
~/Projects/Butterfly $ tail alignment.sam
```



Question

How can I display the first 20 lines of a text file?

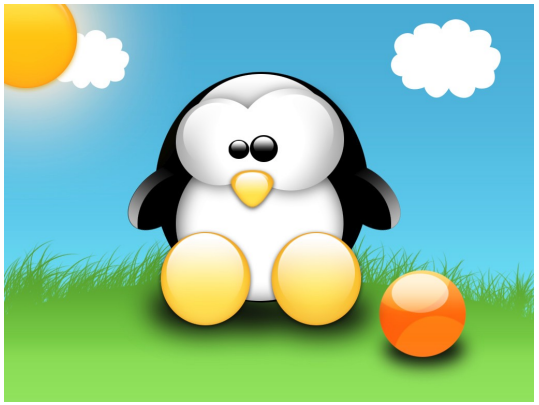
```
~ $ head --help

...

-n, --lines=[-]K    print the first K lines instead of the first 10;
                    with the leading `-', print all but the last
                    K lines of each file
...
```

Using the terminal efficiently

1. use arrow keys



http://z-dark.deviantart.com/art/Tux-Kids-desktop-22363967

VIB JAKONIX

Using the terminal efficiently

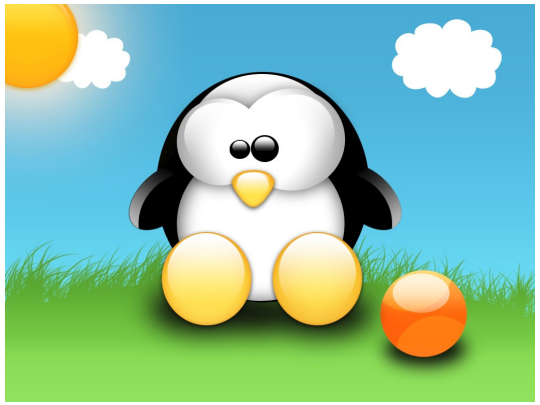
- The program 'history' keeps track of the last ~500 commands you have typed.

```
joachim@joachim-VirtualBox ~ $ history
    1  bowtie
    2  clear
    3  bowtie --version
    4  bowtie --version
    5  ./snap
    6  ./bowtie2
    7  sudo add-apt-repository
    8  sudo add-apt-repository ppa:webupd8team/tribler
    9  sudo apt-get update
   10  sudo apt-get install tribler
   11  tribbler
   12  tribler
   13  ls -l
   14  ls -l
   15  ls -l
   16  ll
```

- Use **arrows** to select previously typed commands

Using the terminal efficiently

1. *use arrow keys*
2. *use tab expansion*



VIB JAKONIX

Using the terminal efficiently

- Autocompletion, aka tab expansion: type the first letters of the program or file, and then press <tab> key.
- `$ cd /h<tab>`
  `$ cd /home/`
  However
  `$ cd /b<tab>` gives you audible feedback:
  - there is no expansion possible
  - there is more than one way to expand

  `$ cd /b<tab><tab>` shows suitable expansions

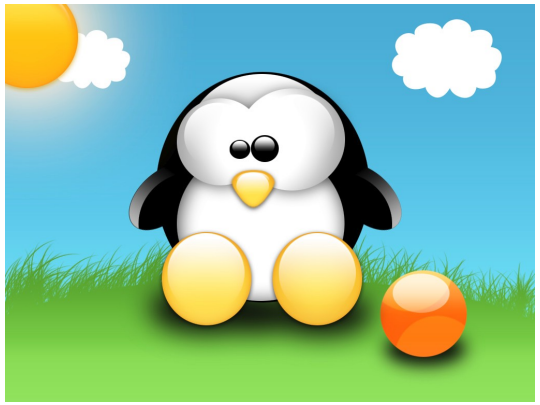
```
bin/ boot/

$ cd /bo<tab>

$ cd /boot/
```

Using the terminal efficiently

1. *use arrow keys*
2. *use tab expansion*
3. *use shorthand notations*



VIB JAKONIX

Using the terminal efficiently

Use shorthand notations for common directories:

- ~ is your home directory
- . is the current directory
- .. is the directory one level up

To execute a previous command `cmd` again you can use:

```
$ !cmd
```

```
e.g. $ !cd
```

Exercise: getting large data files.

→ Exercise link

Keywords

Root directory
path
home
terminal
Command line
user
bash
argument
recursively
command line options

Break