



BASH Essentials

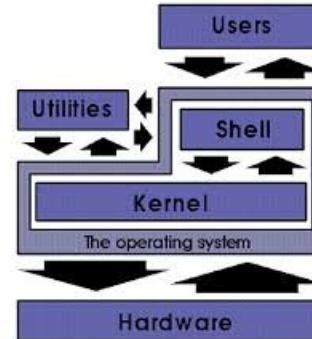
Ádám T. Kocsis

Friedrich-Alexander-Universität Erlangen-Nürnberg

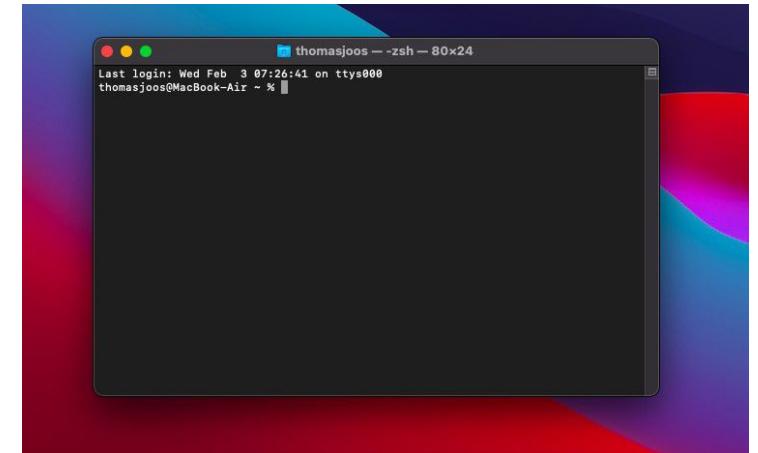
2024-10-07

Terminal emulators

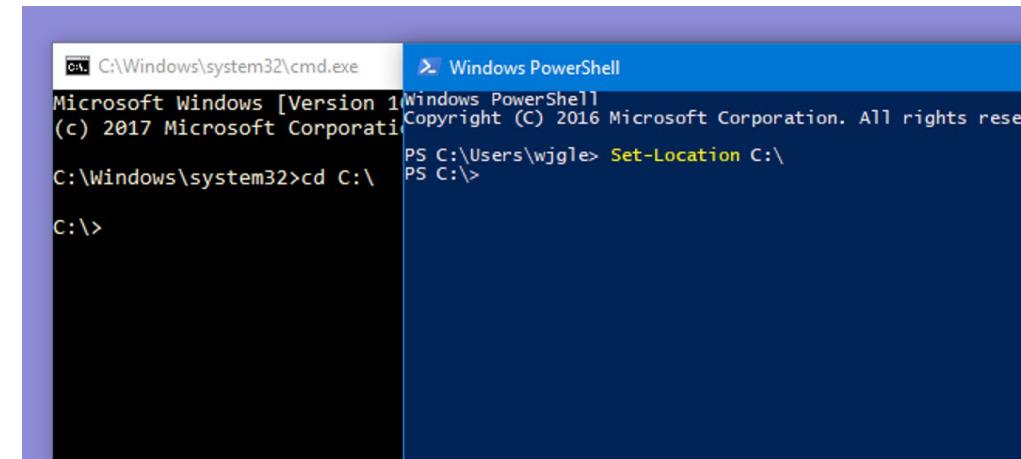
- Every OS has at least one
- Graphical applications that run a program called the “shell”: an interpreter program that translates instructions
- Console applications can be run with the shell
 - Automation
 - Program building
 - Scientific calculations
- Shells are programmable



Mac (zsh or bash)

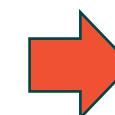


Windows (cmd and powershell)



The BASH shell

- Ubiquitous
- Most frequently used on servers and clusters
- UNIX-native: most programming systems use UNIX-like paths – even on Windows!
- Mac: have it, z shell (zsh) is almost the same
- Windows: a simplified version is available with git (git bash)



<https://git-scm.com>

Installing git for Windows

If you use Mac OS: do nothing!

BASH essentials

Most important functions and browsing directories

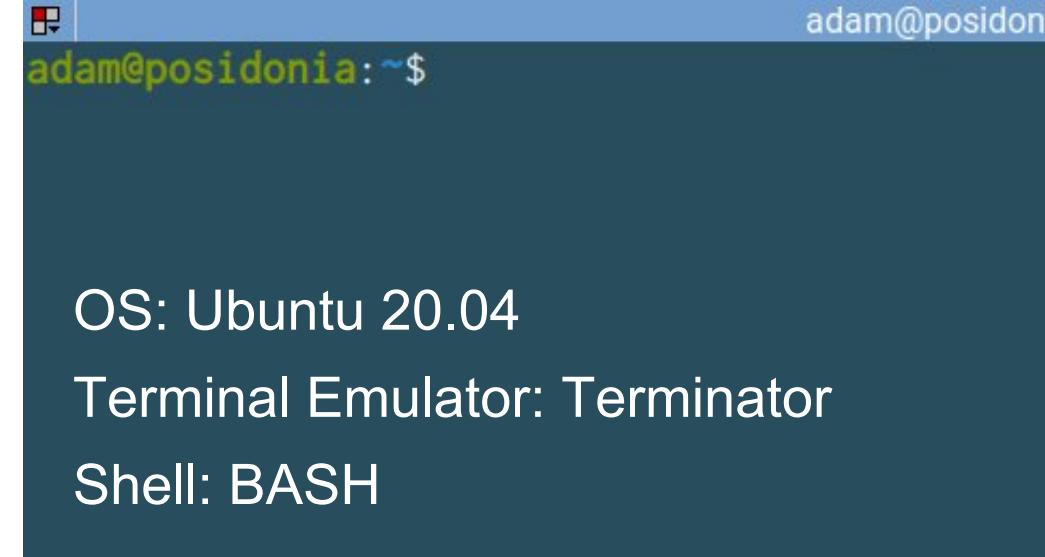
The prompt

- User input expected (typing)
- Looks different on all, but there are conventions:

user@host

~: is shorthand for user home

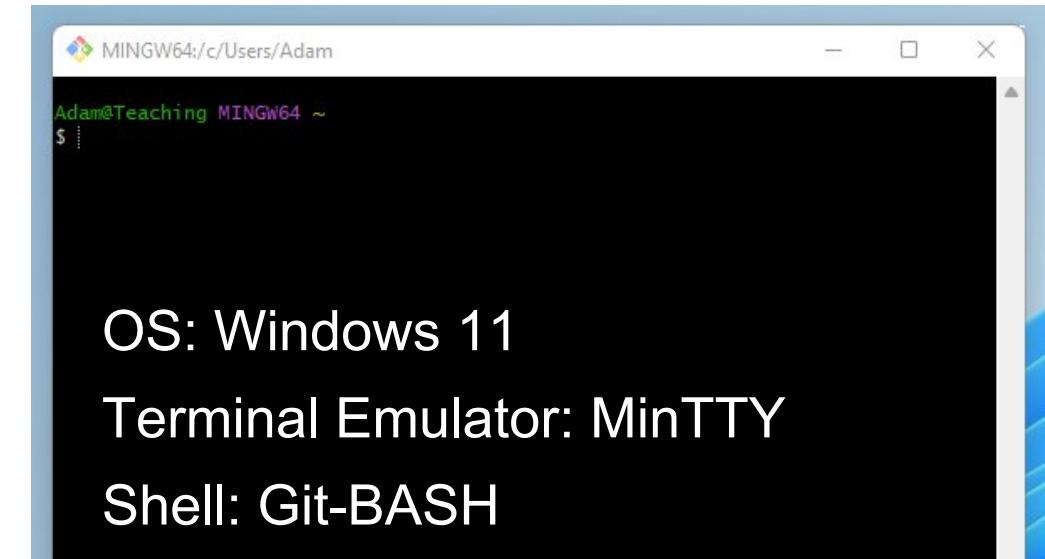
\$: means normal user mode



adam@positon:~\$

OS: Ubuntu 20.04
Terminal Emulator: Terminator
Shell: BASH

This image shows a terminal window from the Terminator emulator on an Ubuntu 20.04 system. The prompt 'adam@positon:~\$' is displayed in green text. The window title bar shows the user 'adam' and the host 'positon'.



MINGW64:/c/Users/Adam

Adam@Teaching MINGW64 ~

\$

OS: Windows 11
Terminal Emulator: MinTTY
Shell: Git-BASH

This image shows a terminal window from MinTTY on a Windows 11 system, running a Git-BASH shell. The prompt 'Adam@Teaching MINGW64 ~' is displayed in green text. The window title bar shows the user 'Adam' and the host 'Teaching'. The shell is identified as 'MINGW64'.

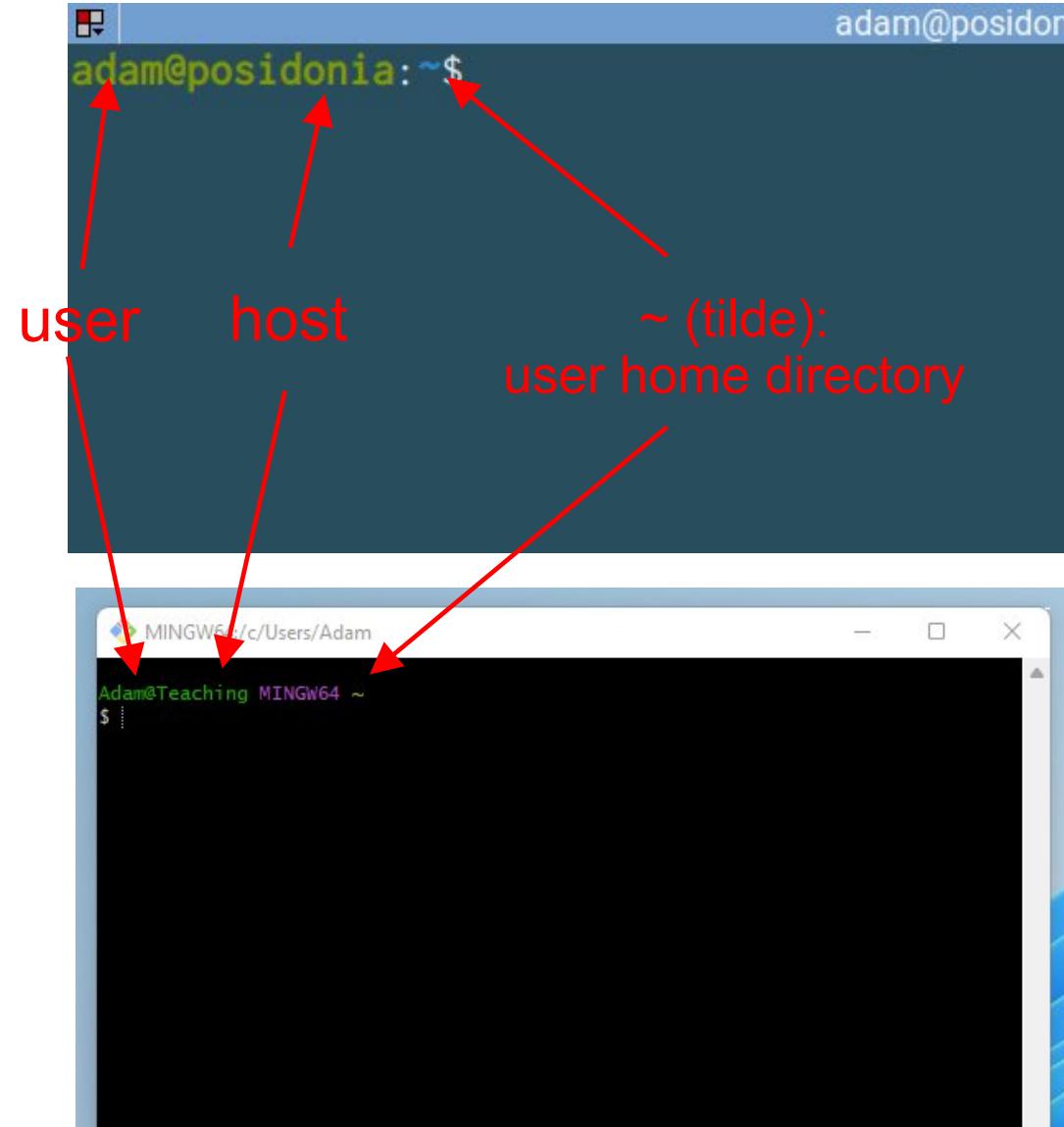
The prompt

- User input expected (typing)
- Looks different on all, but there are conventions:

user@host

~: is shorthand for user home

\$: means normal user mode



pwd

Return path to current directory

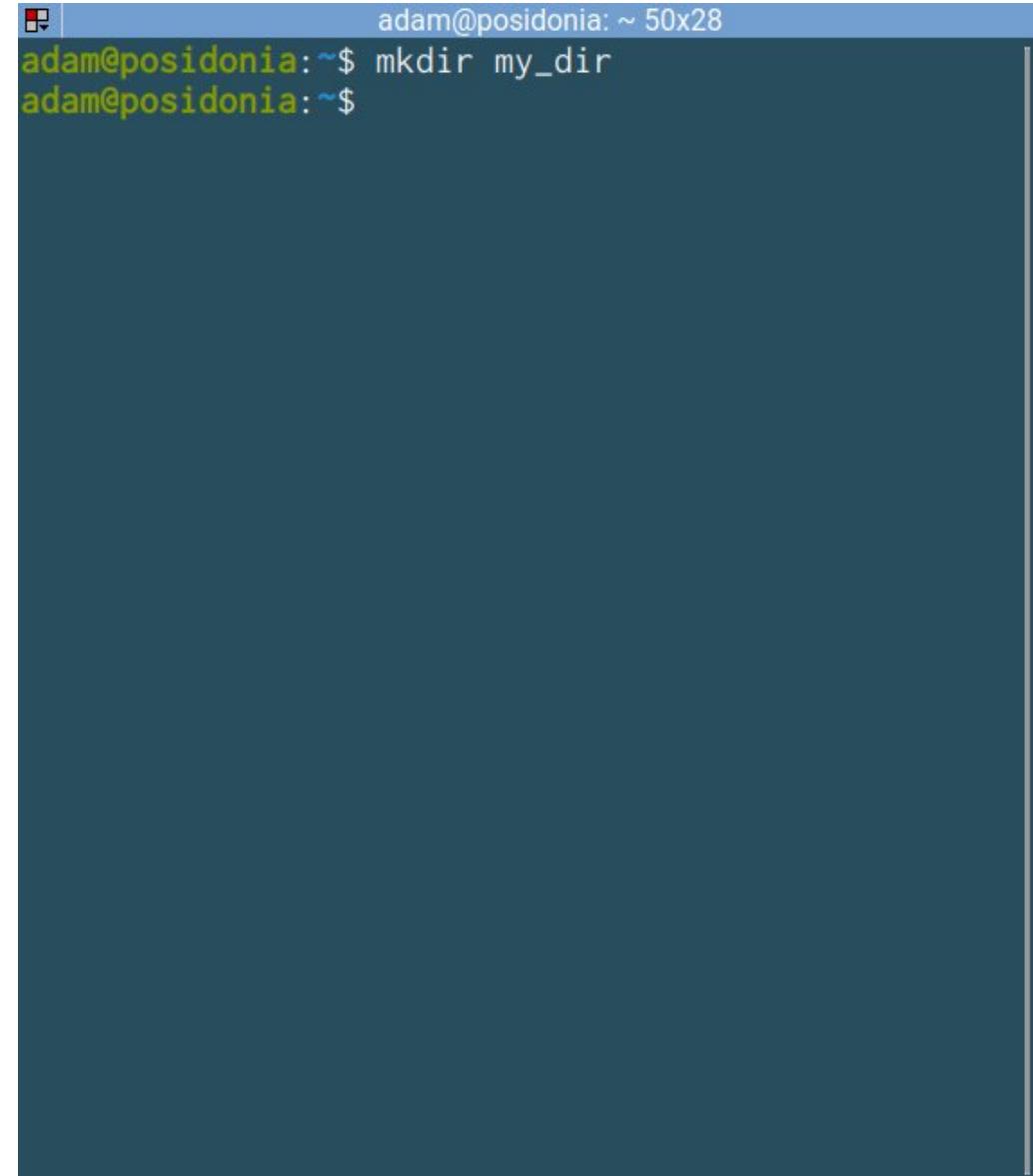
```
adam@positonia: ~ 50x28
adam@positonia: ~$ pwd
/home/adam
adam@positonia: ~$
```

`mkdir <name>`

 space

Create a directory

- No output to the console: no error occurred (directory was created)



adam@positonia: ~ 50x28

```
adam@positonia:~$ mkdir my_dir
adam@positonia:~$
```

ls

List directory contents

- Returns a list of entries (both normal files and directories) – can be colored
- Note the quotes around entries with spaces in them!



```
adam@positonia: ~ 50x28
adam@positonia:~$ ls
01-network-manager-all.yaml      Programs
1_linktags.sh                    Public
Desktop                          random.conf
Documents                         report
Downloads                         snap
Edraw                            some.df
exercises                         Templates
gems                             temp.mbsync
Mail                             Videos
Music                            virtual
my_dir                            'VirtualBox VMs'
'NVIDIA Nsight Systems'          zen.json
Pictures                         Zotero
adam@positonia:~$
```

ls -l

List directory contents (with option l)

- Long output, includes attributes

d:directory

permissions

owner

size (bytes) modification name

```
adam@positonia:~$ ls -l
total 112
-rw-r--r-- 1 adam adam 104 Sep 2 2020 01-network-manager-all.yaml
-rw-r--r-- 1 adam adam 224 Jul 2 13:34 1_linktags.sh
drwxr-xr-x 3 adam adam 4096 Jul 29 19:58 Desktop
drwxrwxr-x 2 adam adam 4096 Dez 16 2021 Documents
drwxr-xr-x 5 adam adam 16384 Aug 19 12:00 Downloads
drwxrwxr-x 3 adam adam 4096 Sep 5 2020 Edraw
drwxrwxr-x 3 adam adam 4096 Okt 14 2021 exercises
drwxrwxr-x 10 adam adam 4096 Aug 15 14:40 gems
drwxrwxr-x 7 adam adam 4096 Jan 24 2022 Mail
drwxr-xr-x 2 adam adam 4096 Sep 1 2020 Music
drwxrwxr-x 2 adam adam 4096 Aug 19 16:09 my_dir
drwxrwxr-x 2 adam adam 4096 Apr 21 15:34 'NVIDIA Nsight Systems'
drwxr-xr-x 2 adam adam 4096 Sep 1 2020 Pictures
drwxrwxr-x 4 adam adam 4096 Apr 28 2021 Programs
drwxr-xr-x 2 adam adam 4096 Sep 1 2020 Public
-rw-rw-r-- 1 adam adam 9 Aug 17 17:39 random.conf
drwxrwxr-x 3 adam adam 4096 Jun 2 12:36 report
drwx----- 5 adam adam 4096 Jun 4 2021 snap
drwxr-xr-x 2 adam adam 4096 Okt 23 2020 some.df
drwxr-xr-x 2 adam adam 4096 Sep 1 2020 Templates
-rw-rw-r-- 1 adam adam 0 Jan 24 2022 temp.mbsync
drwxr-xr-x 3 adam adam 4096 Mai 16 16:07 Videos
drwxrwxr-x 3 adam adam 4096 Jan 25 2019 virtual
drwxrwxr-x 5 adam adam 4096 Mai 30 10:38 'VirtualBox VMs'
-rw-rw-r-- 1 adam adam 154 Mär 16 13:11 zen.json
drwxr-xr-x 9 adam adam 4096 Aug 18 22:36 Zotero
adam@positonia:~$
```

```
cd <path_to_directory>
```

Go to a directory

- Can be relative or absolute!

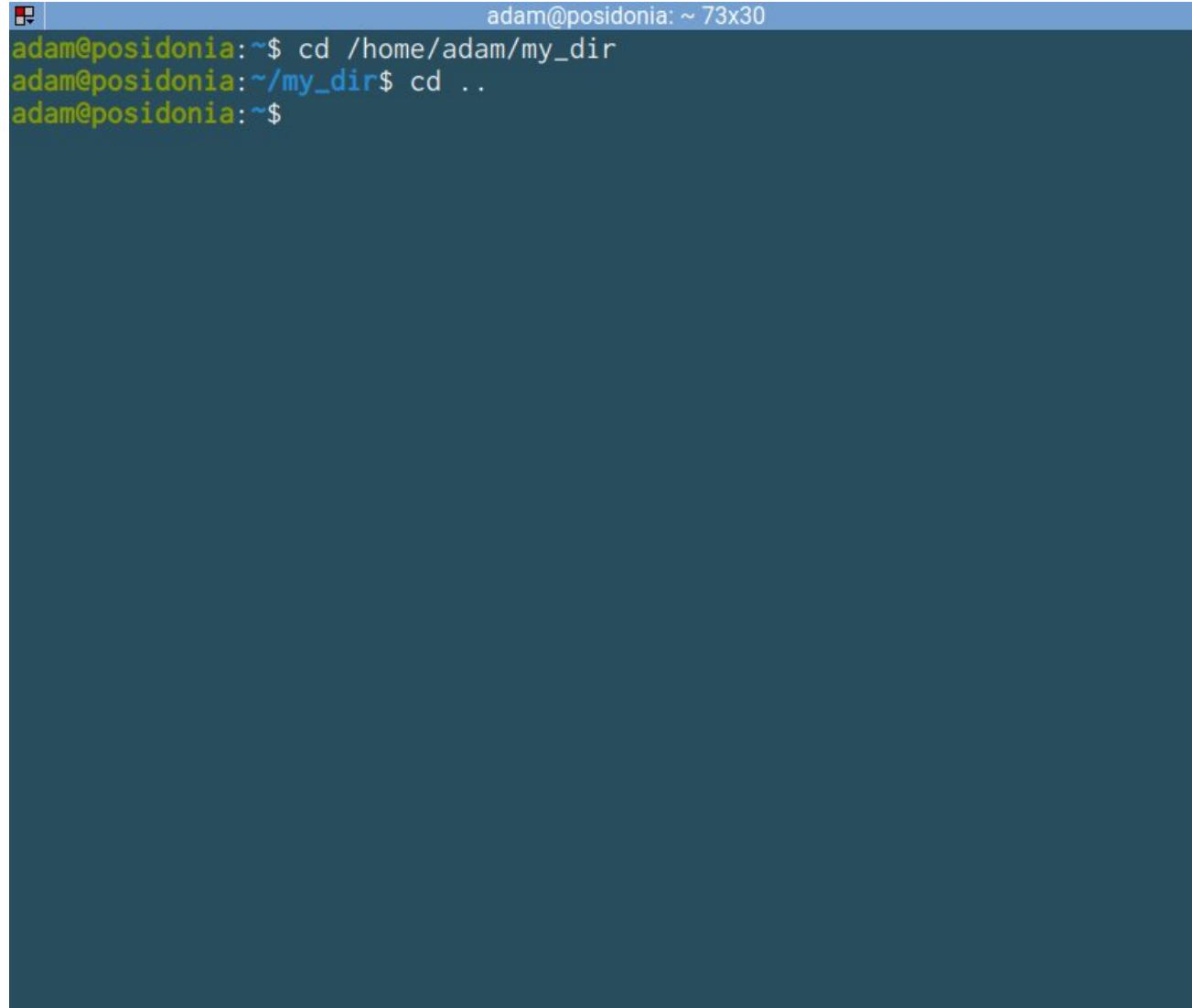
```
adam@positonia: ~/my_dir 73x30
adam@positonia:~$ cd my_dir
adam@positonia:~/my_dir$
```

```
adam@positonia: ~/my_dir 73x30
adam@positonia:~$ cd /home/adam/my_dir
adam@positonia:~/my_dir$
```

cd ..

Go to parent directory

- .. (dot dot) is a placeholder for the parent of the current directory (one up in the hierarchy)



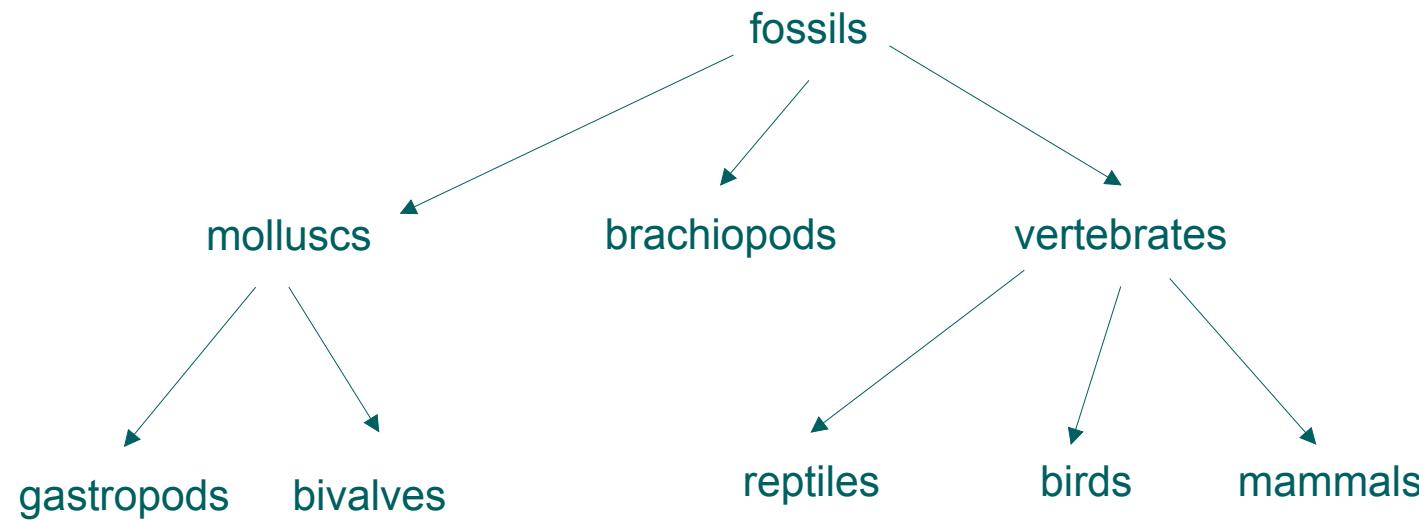
A screenshot of a terminal window titled "adam@posidonia: ~ 73x30". The window shows the following command sequence:

```
adam@posidonia:~$ cd /home/adam/my_dir
adam@posidonia:~/my_dir$ cd ..
adam@posidonia:~$
```

The terminal is a dark blue color with white text. The command "cd /home/adam/my_dir" changes the directory to "/home/adam/my_dir". The command "cd .." then changes the directory back to the parent directory, which is the user's home directory, indicated by the prompt "adam@posidonia:~\$".

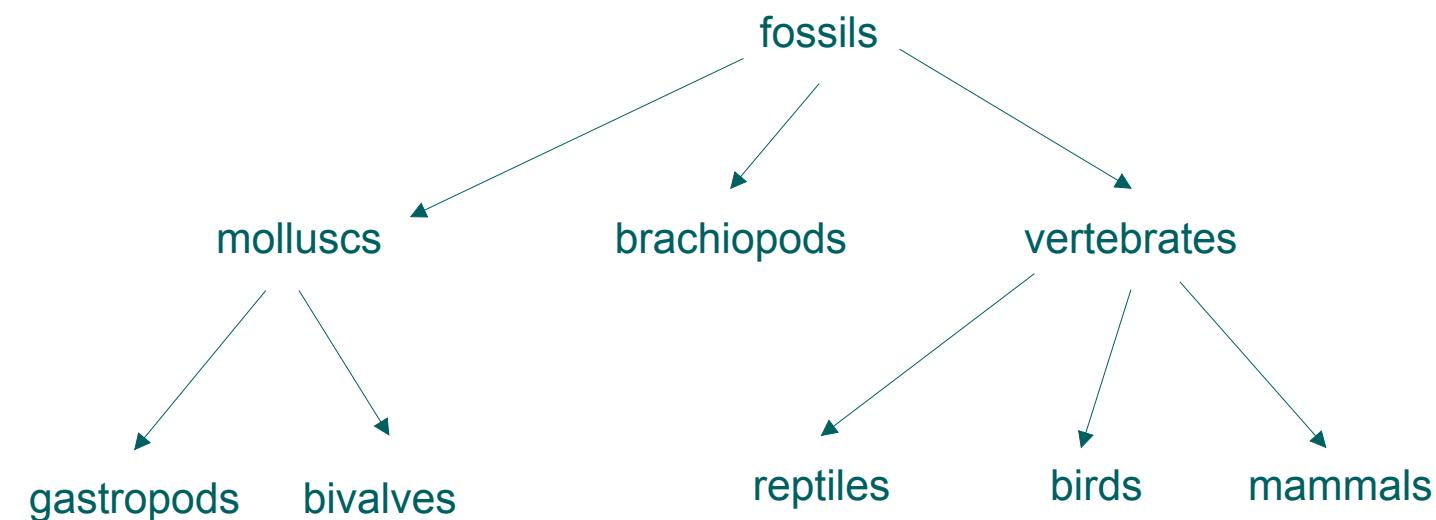
Exercise (5 minutes)

- Create this directory structure using the combinations of the previous commands!



Exercise (5 minutes)

- Create this directory structure using the combinations of the previous commands!

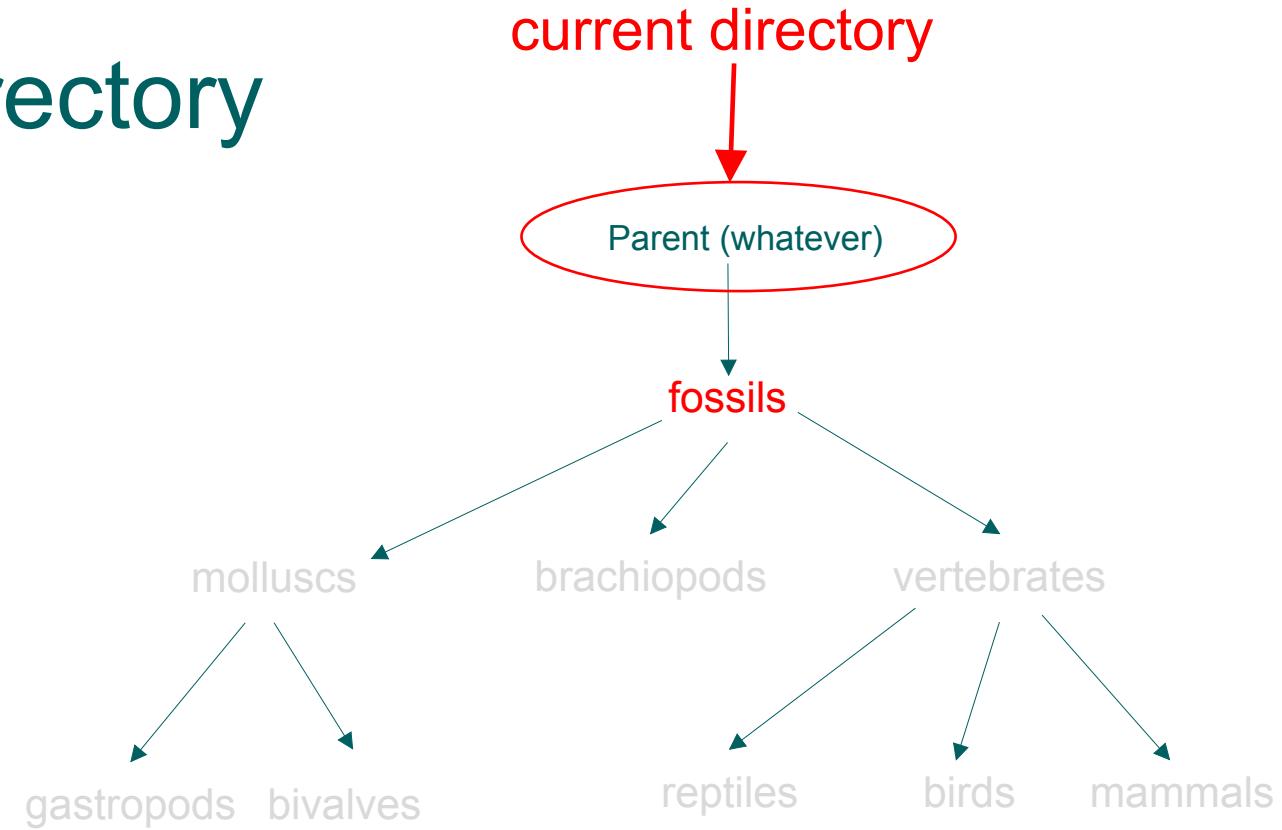


Hints

- use <TAB> completion (try <TAB> <TAB> to see multiple solutions)
- use <UP> and <DOWN> to search command history for already given commands

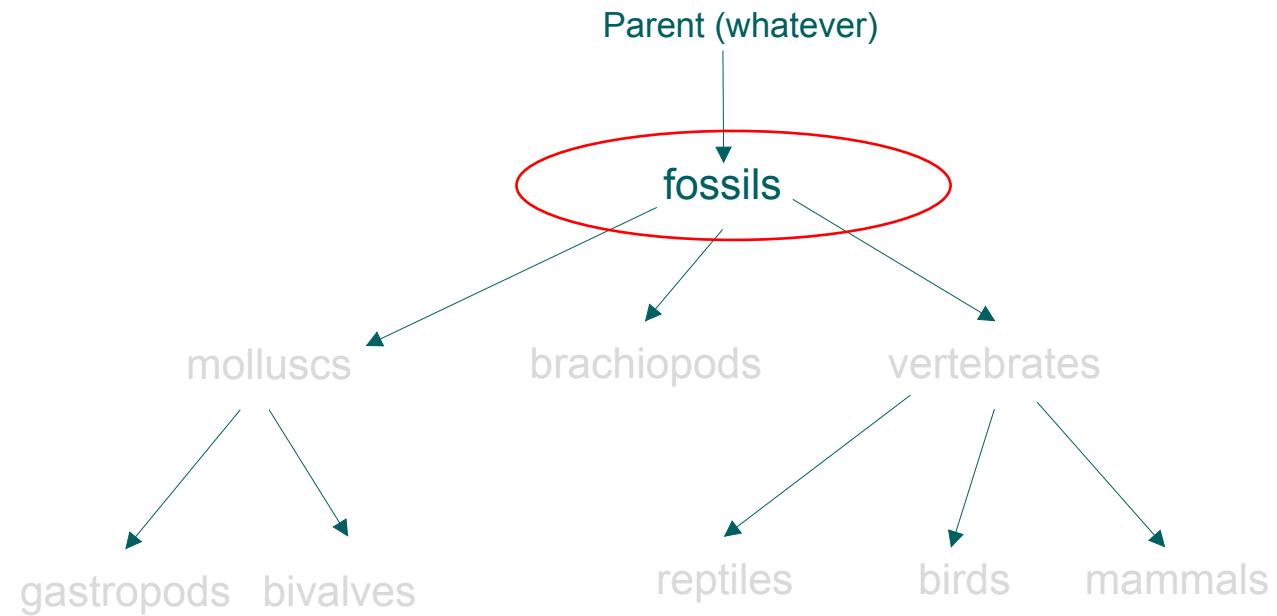
Solution 1 – changing directory

```
adam@posidonia: ~/fossils/vertebrates 73x30
adam@posidonia:~$ mkdir fossils
adam@posidonia:~$ cd fossils
adam@posidonia:~/fossils$ mkdir molluscs
adam@posidonia:~/fossils$ mkdir brachiopods vertebrates
adam@posidonia:~/fossils$ cd molluscs
adam@posidonia:~/fossils/molluscs$ mkdir gastropods bivalves
adam@posidonia:~/fossils/molluscs$ cd ..
adam@posidonia:~/fossils$ cd vertebrates
adam@posidonia:~/fossils/vertebrates$ mkdir reptiles birds mammals
adam@posidonia:~/fossils/vertebrates$
```



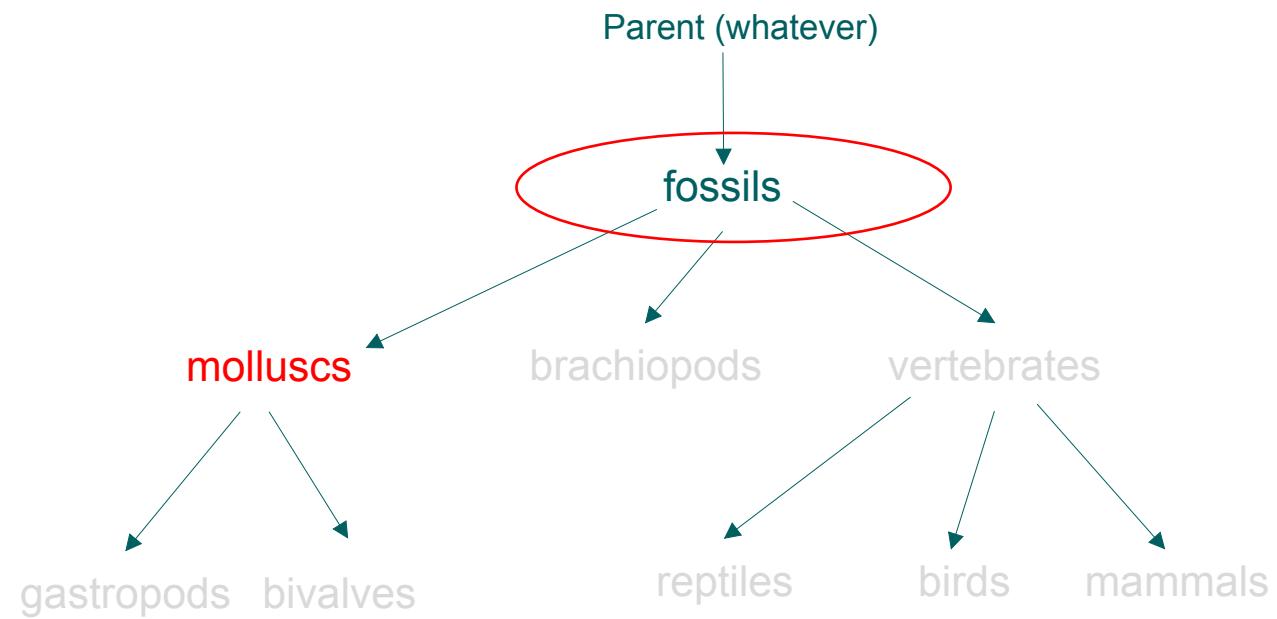
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adam@posidonia:~/fossils/vertebrates$
```



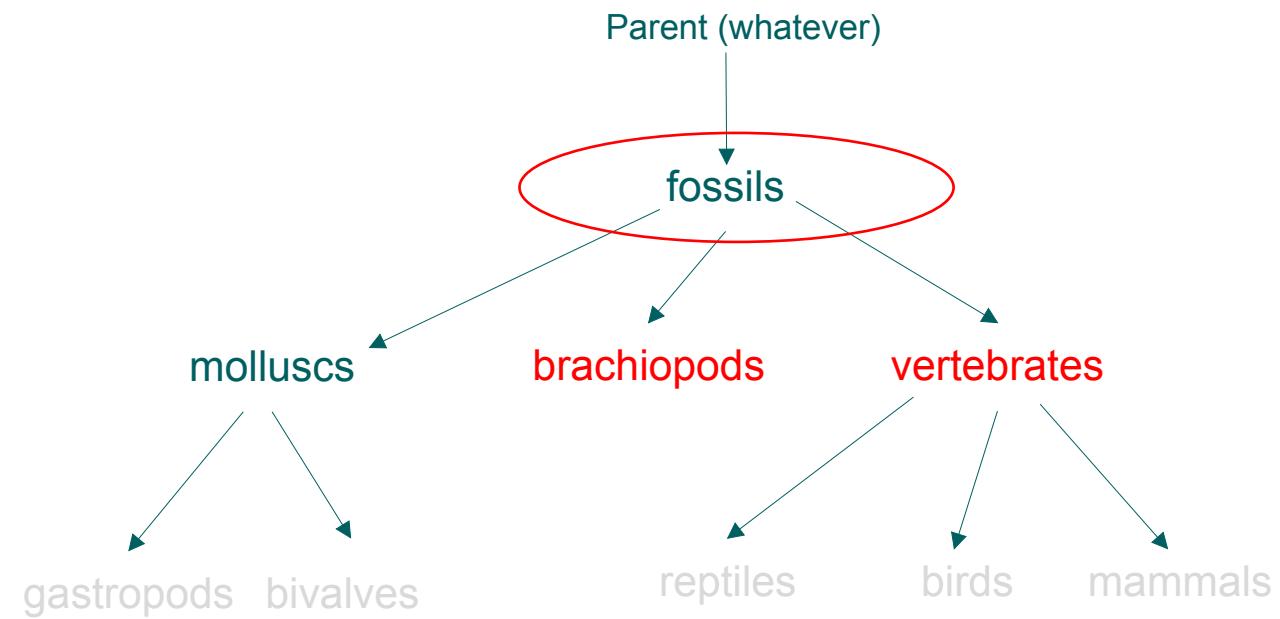
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```



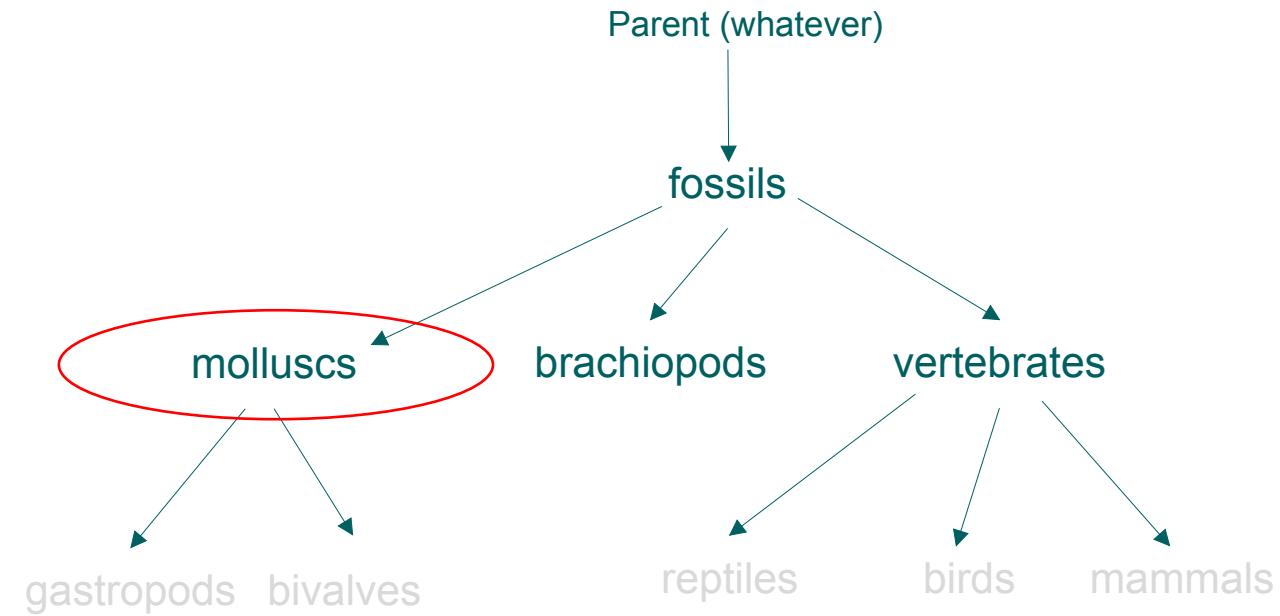
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```



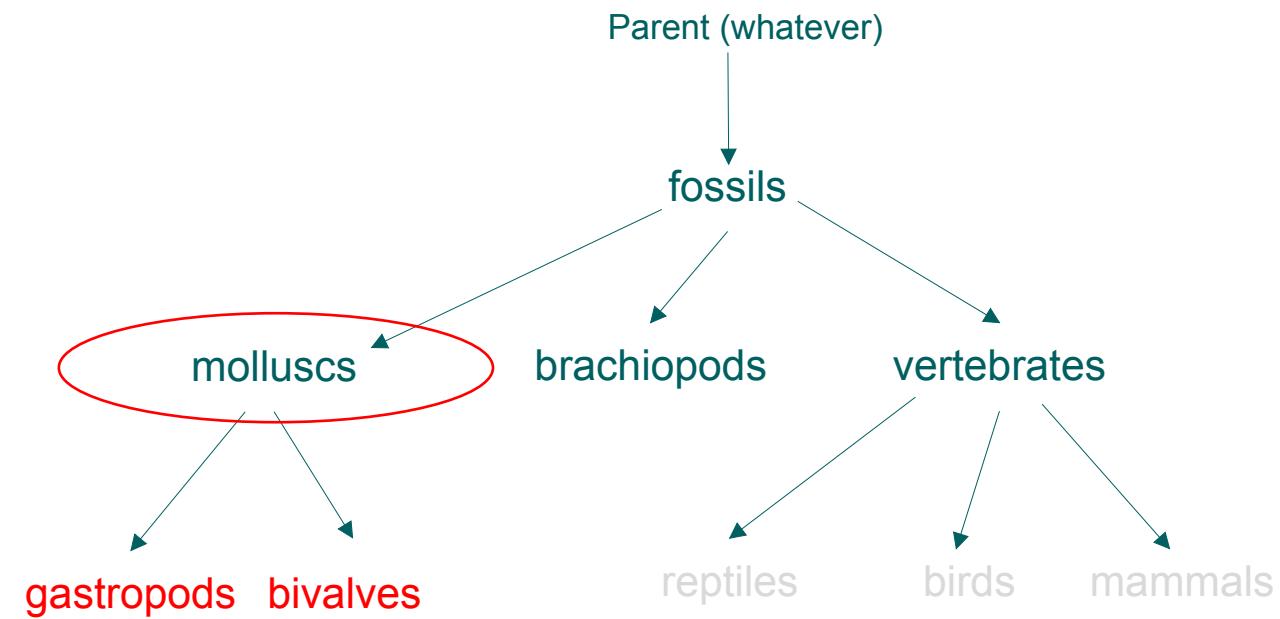
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```



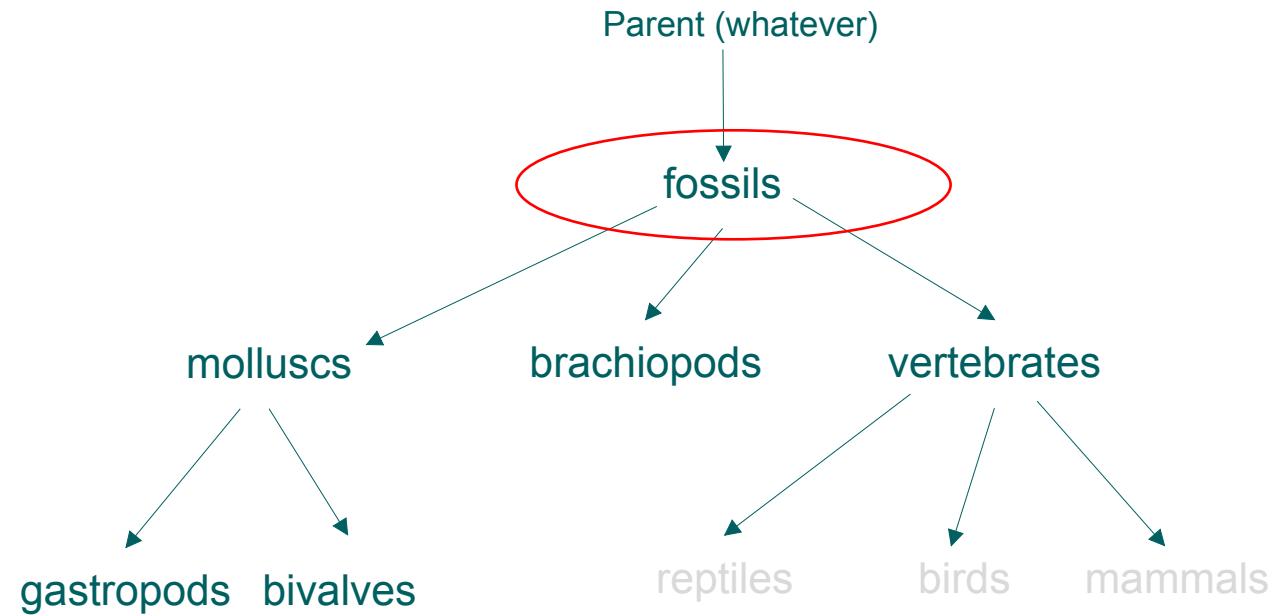
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```



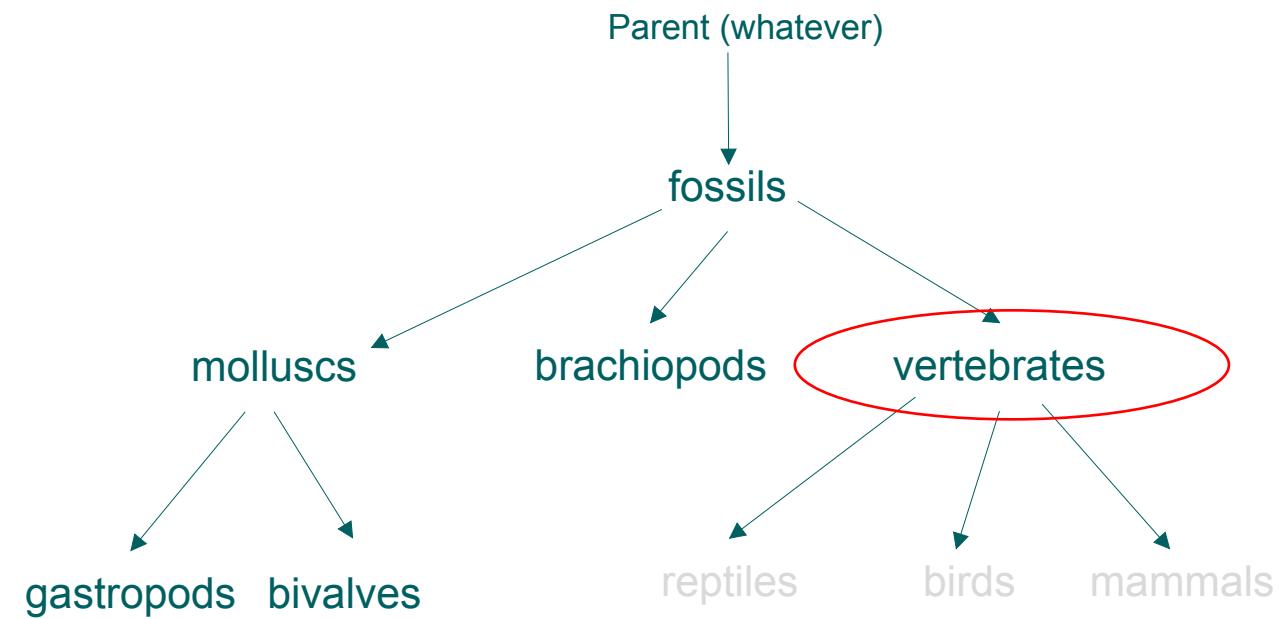
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adam@posidonia:~/fossils/vertebrates$
```



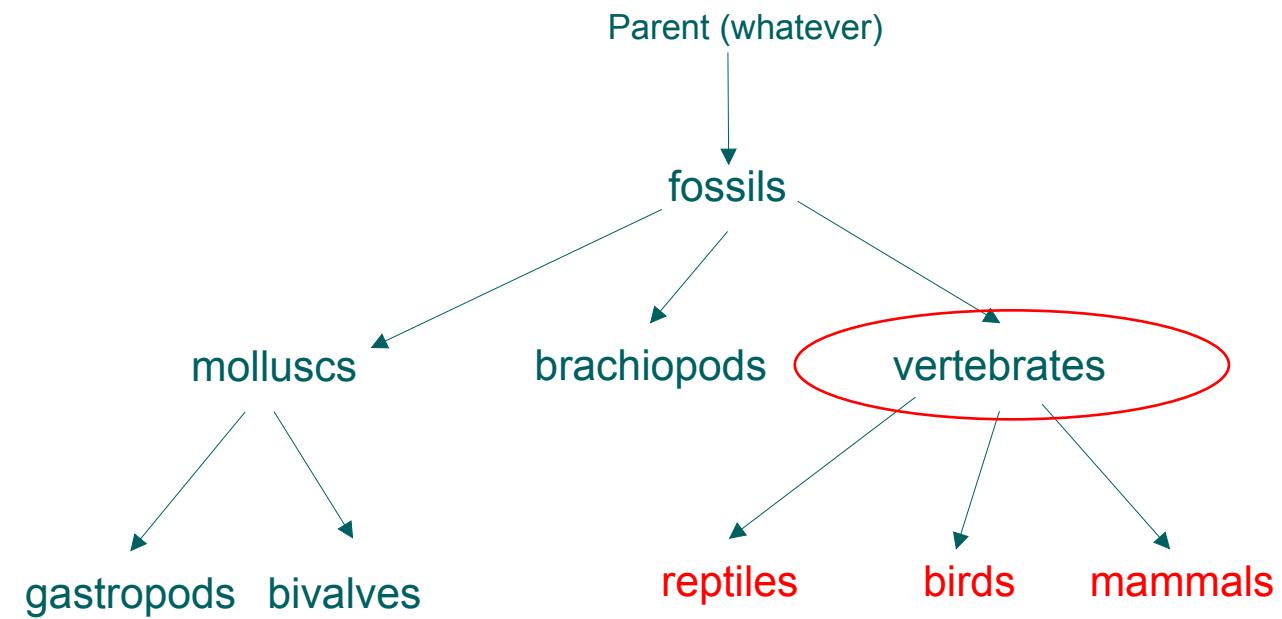
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```



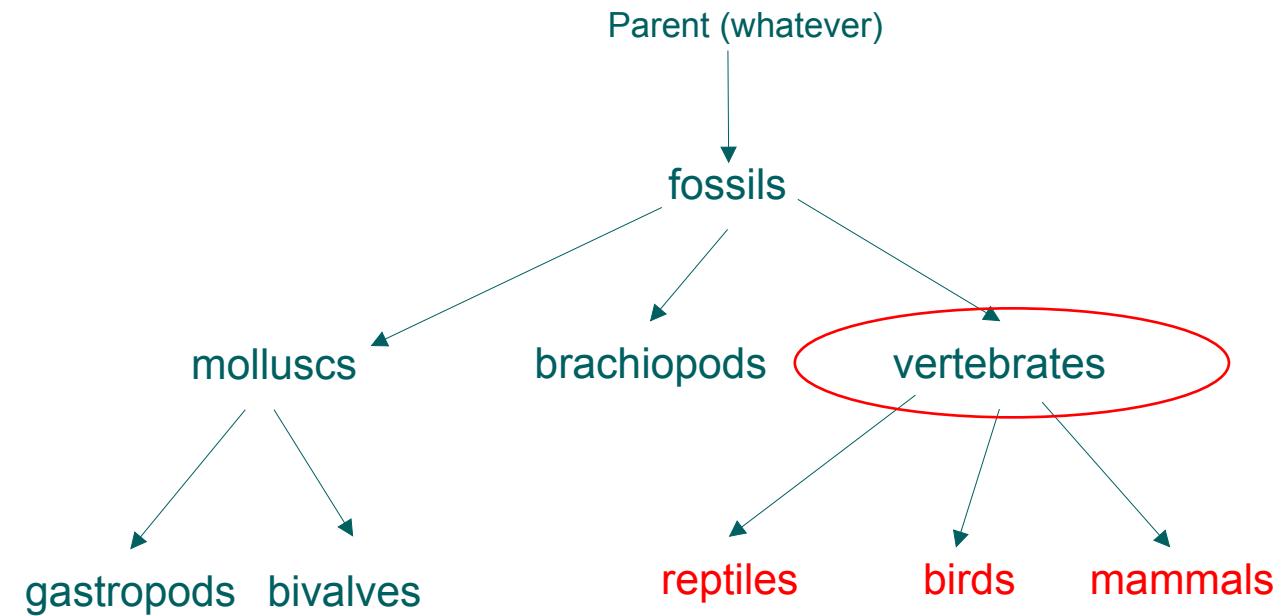
Solution 1 – changing directory

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adam@posidonia: ~$ mkdir fossils
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adam@posidonia: ~/fossils/molluscs$ cd ..
adam@posidonia: ~/fossils$ cd vertebrates
adam@posidonia: ~/fossils/vertebrates$ mkdir reptiles birds mammals
adam@posidonia: ~/fossils/vertebrates$
```



Solution 1 – changing directory

```
adam@posidonia:~/fossils/vertebrates 73x30
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adam@posidonia:~/fossils/vertebrates$
```

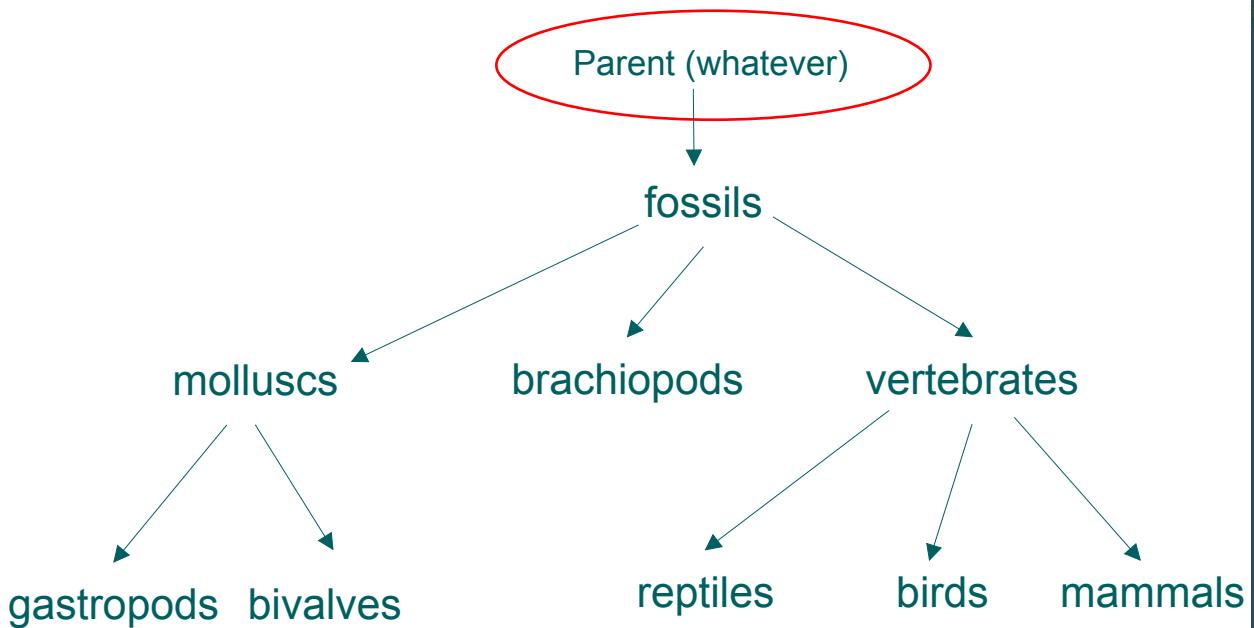


How to check?

find_<path to directory>

Recursive listing

- 1. Go back to the parent
- 2. Use find there!



```
adam@posidonia: ~/fossils/vertebrates$ cd ../../
adam@posidonia:~/fossils$ find fossils
fossils
fossils/molluscs
fossils/molluscs/gastropods
fossils/molluscs/bivalves
fossils;brachiopods
fossils/vertebrates
fossils/vertebrates/reptiles
fossils/vertebrates/birds
fossils/vertebrates/mammals
adam@posidonia:~$
```

parent of parent

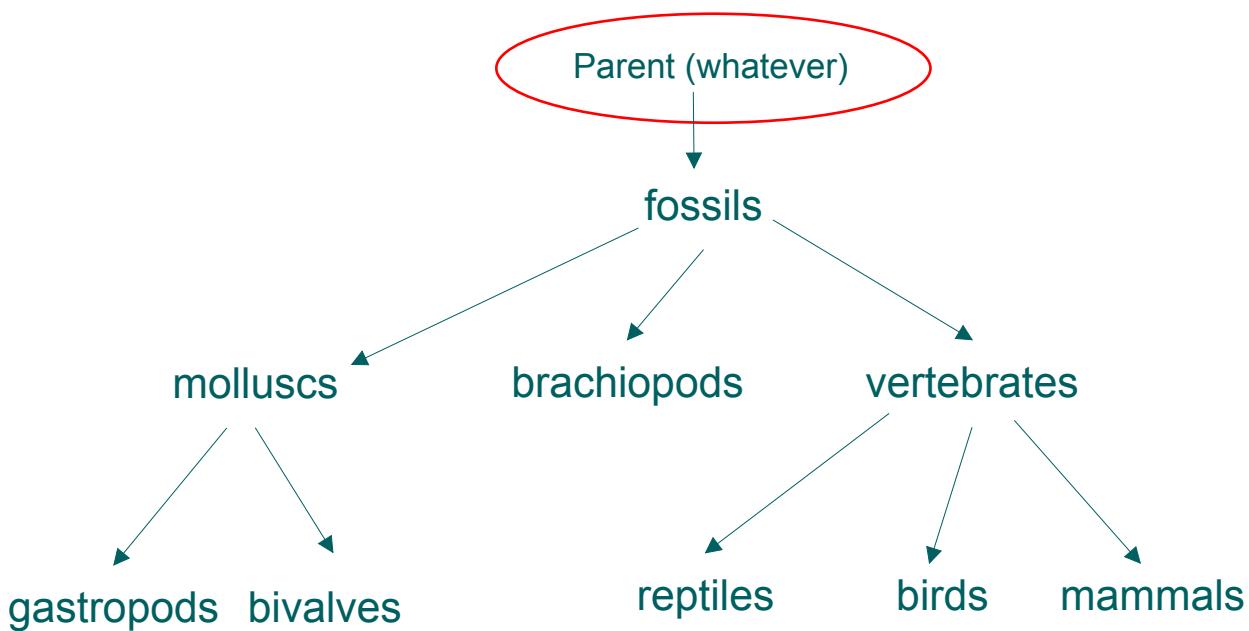
relative paths

find <path> > <path_to_file>

Angled bracket or **chevron**

Output redirection

- Whatever was output to the console is now in a new file!



```
adam@posidonia:~/fossils/vertebrates$ cd ../../
adam@posidonia:~/fossils$ find fossils
fossils
fossils/molluscs
fossils/molluscs/gastropods
fossils/molluscs/bivalves
fossils/brachiopods
fossils/vertebrates
fossils/vertebrates/reptiles
fossils/vertebrates/birds
fossils/vertebrates/mammals
adam@posidonia:~/fossils > fossil_path.txt
adam@posidonia:~$
```

“>” Will overwrite existing files!

Suggested nomenclature

() : **Parenthesis** (open and close)

[] : **Bracket** (open and close)

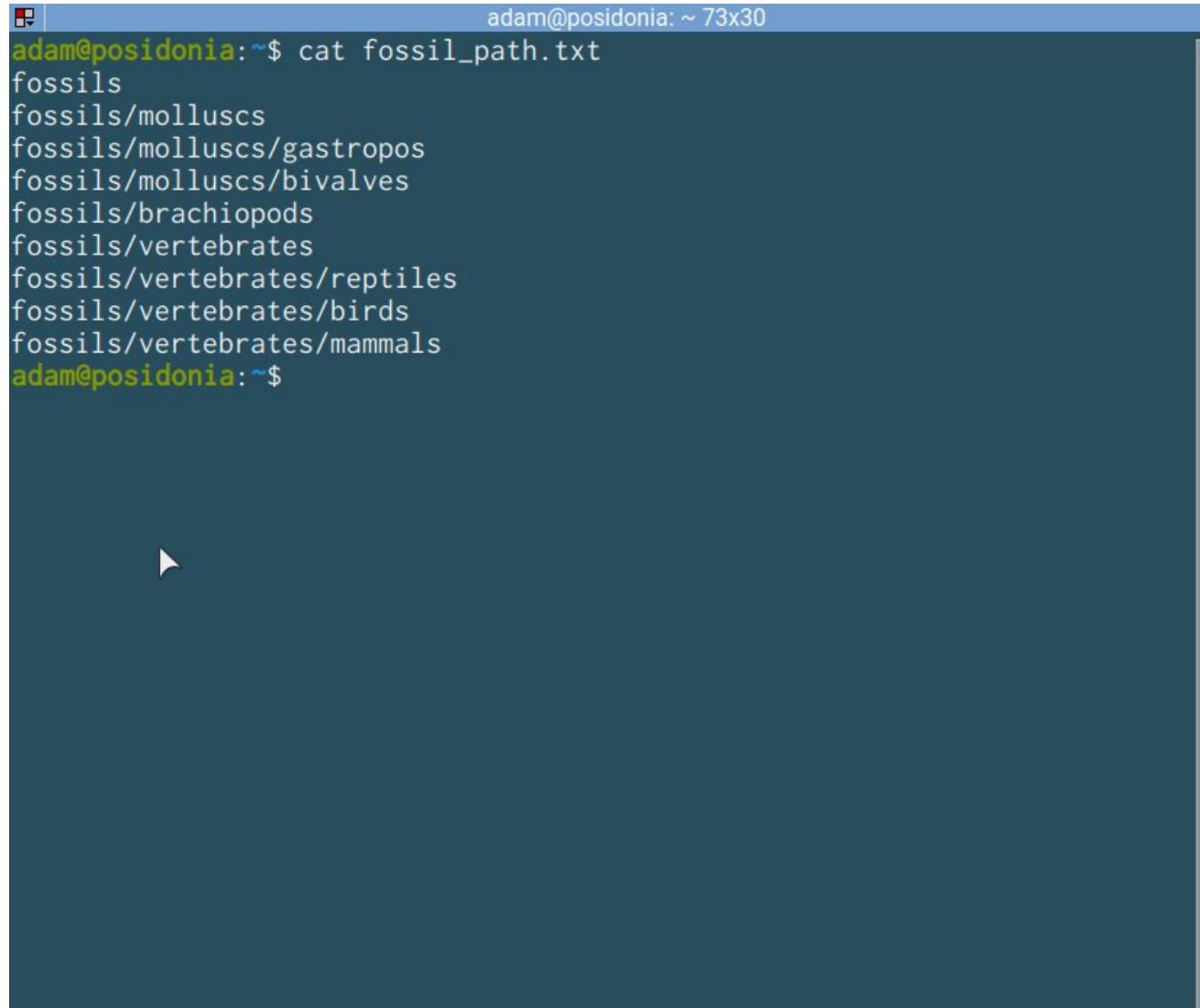
{ } : **Brace** (open and close)

< > : **Chevrons** (left and right)

`cat <path to file>`

Display contents of file

- Exactly as it was output to the console



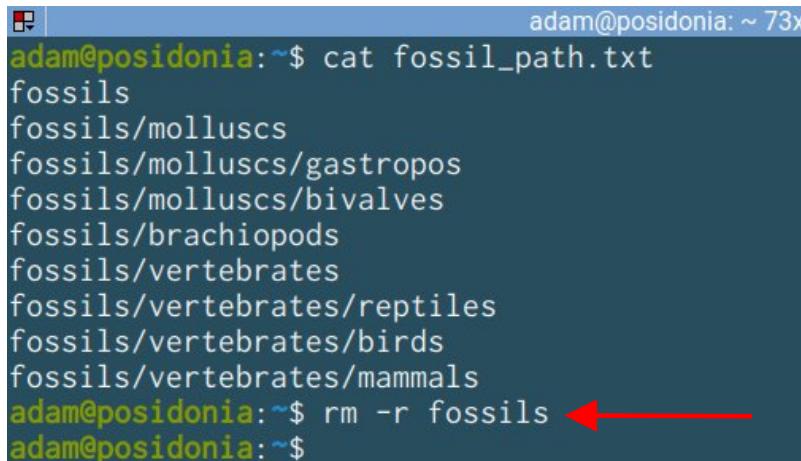
adam@posidonia: ~ 73x30

```
adam@posidonia:~$ cat fossil_path.txt
fossils
fossils/molluscs
fossils/molluscs/gastropods
fossils/molluscs/bivalves
fossils/brachiopods
fossils/vertebrates
fossils/vertebrates/reptiles
fossils/vertebrates/birds
fossils/vertebrates/mammals
adam@posidonia:~$
```

`rm -r <path to dir>`

Recursive deletion (-r)

- Deletes the content of the directory and the directory itself
- rmdir doesn't work! for the
- No output = success?!



adam@posidonia:~\$ cat fossil_path.txt

```
fossils
fossils/molluscs
fossils/molluscs/gastropods
fossils/molluscs/bivalves
fossils/brachiopods
fossils/vertebrates
fossils/vertebrates/reptiles
fossils/vertebrates/birds
fossils/vertebrates/mammals
```

adam@posidonia:~\$ rm -r fossils ←

adam@posidonia:~\$

WARNING!
The results of rm
cannot be undone!

echo <text>

Print something

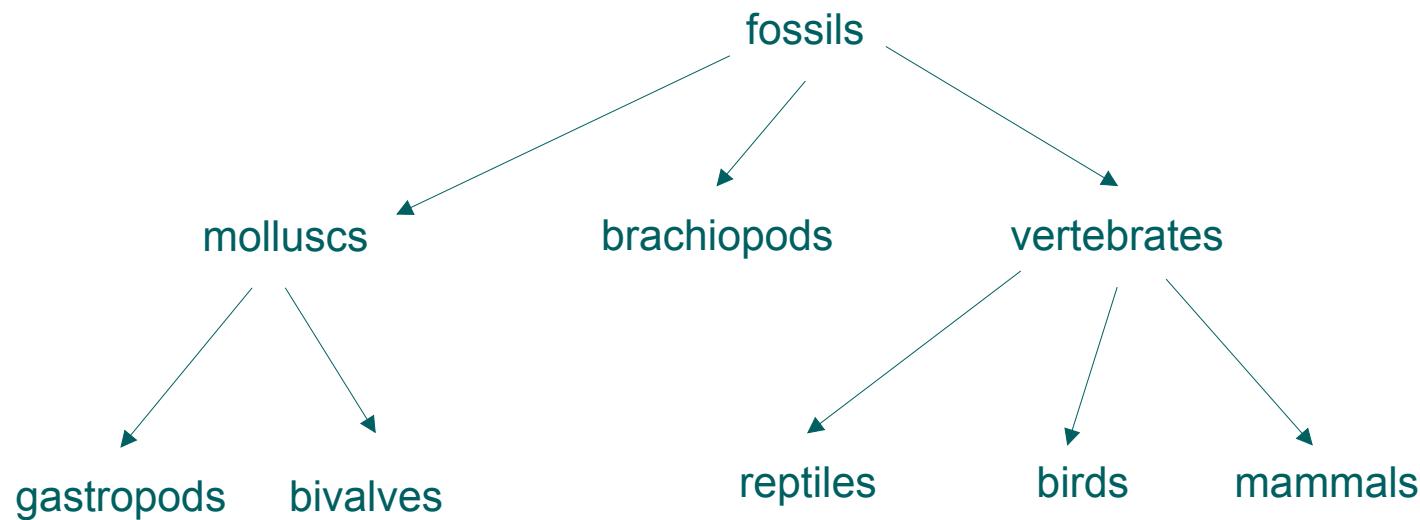
- Used to print things to the console (standard output)
- \$? Is a special symbol: the exit code of the last command:
 - 0: Success
 - Other: Failure

<https://www.redhat.com/sysadmin/exit-codes-demystified>

```
adam@positonia:~$ cat fossil_path.txt
fossils
fossils/molluscs
fossils/molluscs/gastropos
fossils/molluscs/bivalves
fossils;brachiopods
fossils/vertebrates
fossils/vertebrates/reptiles
fossils/vertebrates/birds
fossils/vertebrates/mammals
adam@positonia:~$ rm -r fossils
adam@positonia:~$ echo $? ←
0
adam@positonia:~$
```

Recreate the structure!

- Did you type things into the console?!



Hint 1. Use a general-purpose text editor!

Novice-friendly:

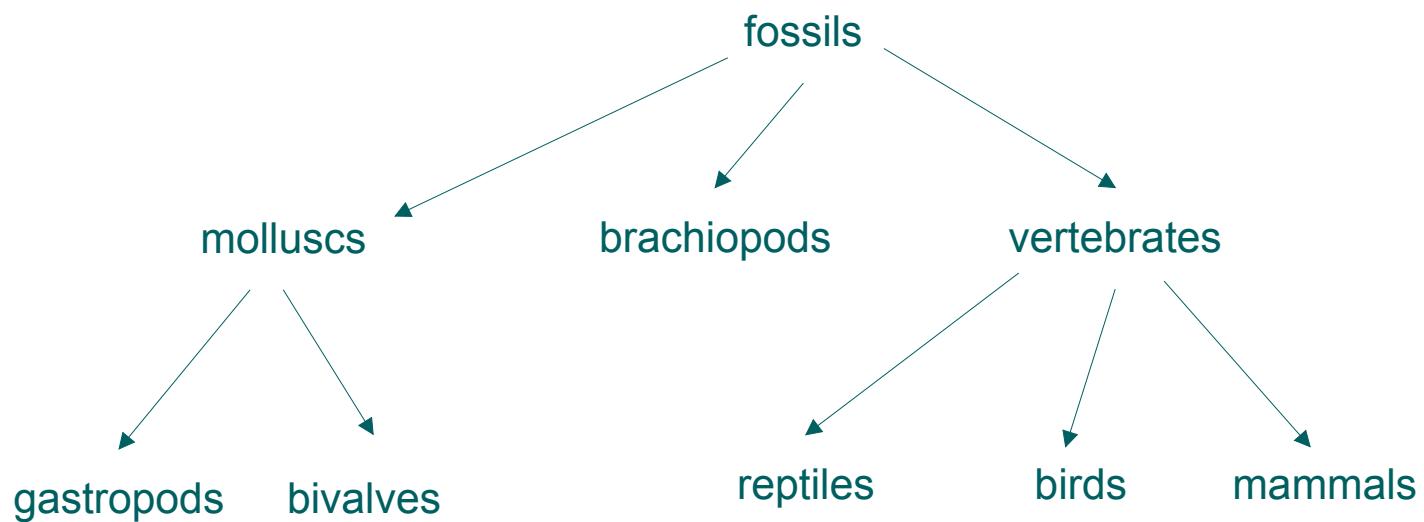
- Sublime Text 
- VS Code 
- Atom 

Expert-friendly:

- Vim 
- Emacs 

Solution 2

- Using the same reference directory



Hint 2. we can use the contents of `fossil_path.txt`

Add `mkdir` in front of every line, then copy and paste into the console!

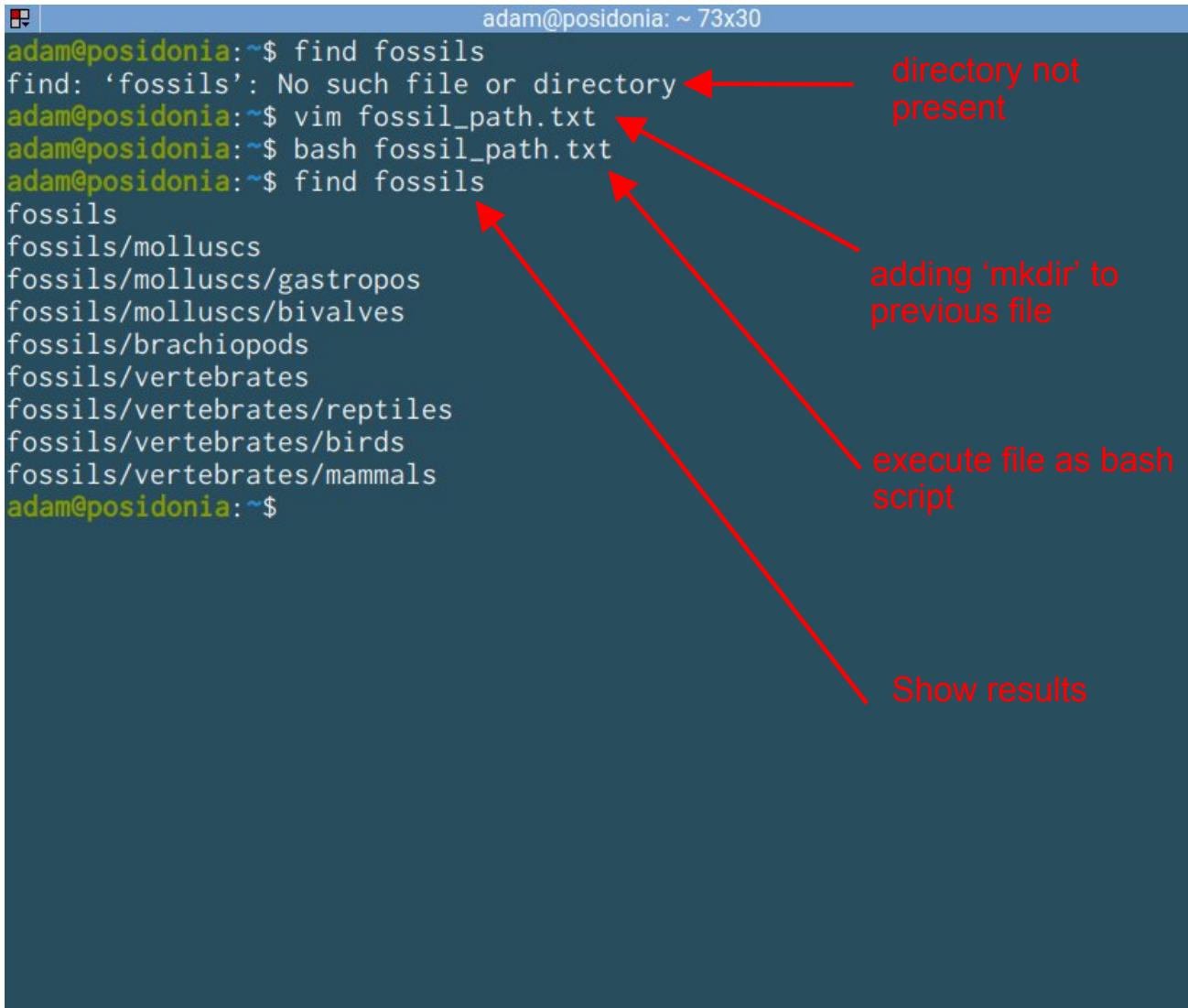
```
1 mkdir fossils
2 mkdir fossils/molluscs
3 mkdir fossils/molluscs/gastropods
4 mkdir fossils/molluscs/bivalves
5 mkdir fossils/brachiopods
6 mkdir fossils/vertebrates
7 mkdir fossils/vertebrates/reptiles
8 mkdir fossils/vertebrates/birds
9 mkdir fossils/vertebrates/mammals
```

bash_<path>

Executing shell scripts

- The text we created is actually a shell script
- The “bash” console application program can be used to execute it.

<https://www.redhat.com/sysadmin/exit-codes-demystified>



```
adam@positonia:~$ find fossils
find: 'fossils': No such file or directory
adam@positonia:~$ vim fossil_path.txt
adam@positonia:~$ bash fossil_path.txt
adam@positonia:~$ find fossils
fossils
fossils/molluscs
fossils/molluscs/gastropos
fossils/molluscs/bivalves
fossils/brachiopods
fossils/vertebrates
fossils/vertebrates/reptiles
fossils/vertebrates/birds
fossils/vertebrates/mammals
adam@positonia:~$
```

directory not present

adding 'mkdir' to previous file

execute file as bash script

Show results

bash --version

Running console applications

- **--version**: ask for program version
- **--help**: display help for program

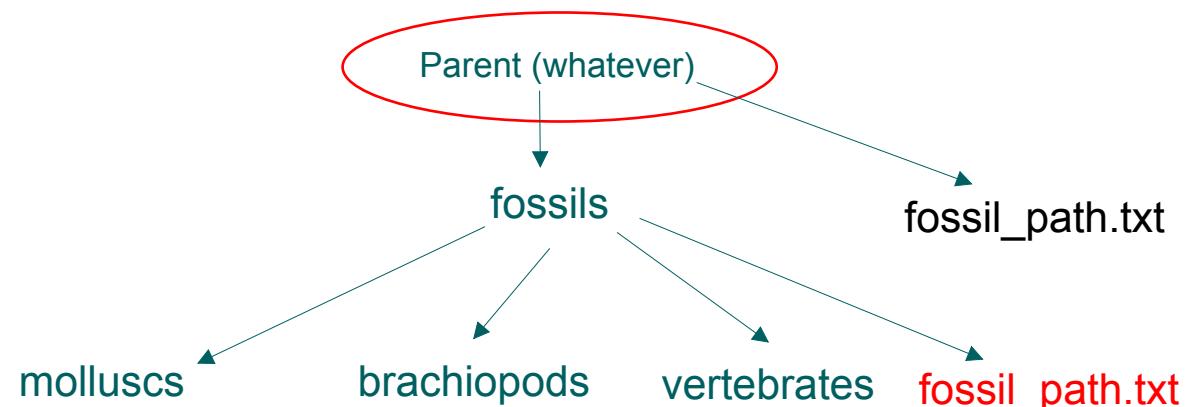
```
adam@positonia:~$ bash --version
bash --version
GNU bash, version 5.0.17(1)-release (x86_64-pc-linux-gnu)
Copyright (C) 2019 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.h
tml>

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adam@positonia:~$
```

`cp <what> <where>`

Copying a file or directory

- Target directory or file
- If directory, the file will be put into it



```
adam@positonia: ~ 73x30
adam@positonia:~$ cp fossil_path.txt fossils
adam@positonia:~$ ls fossils
brachiopods fossil_path.txt molluscs vertebrates
adam@positonia:~$
```

Red annotations on the screenshot:

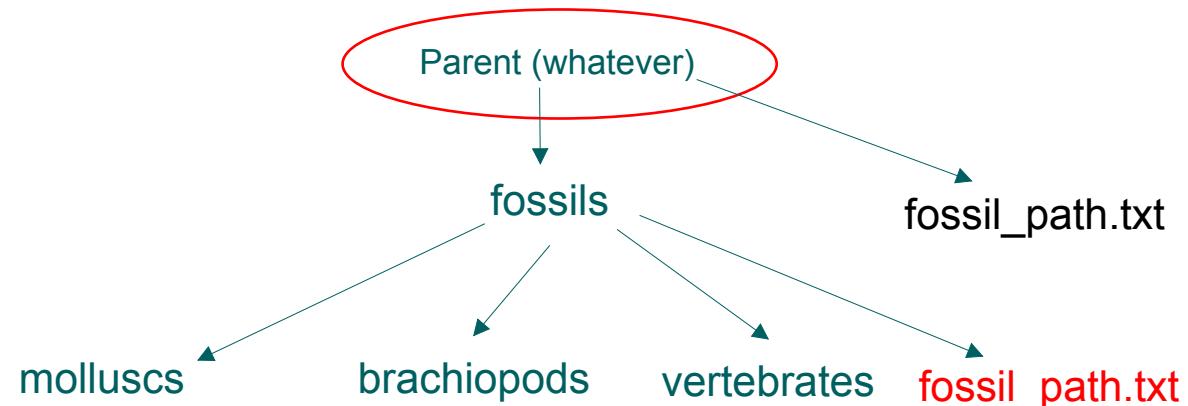
- An arrow points from the word "fossils" in the command line to the "fossils" directory in the file list, with the text "List contents of path!".
- An arrow points from the word "fossil_path.txt" in the command line to the "fossil_path.txt" file in the file list, with the text "New file".

One of the tools that we looked at can be used to delete the file that we have created. Try to delete it!

```
rm <path_file>
```

Without `-r` removes a single file

- As with `cp`, multiple files can be passed to this (separated by spaces)

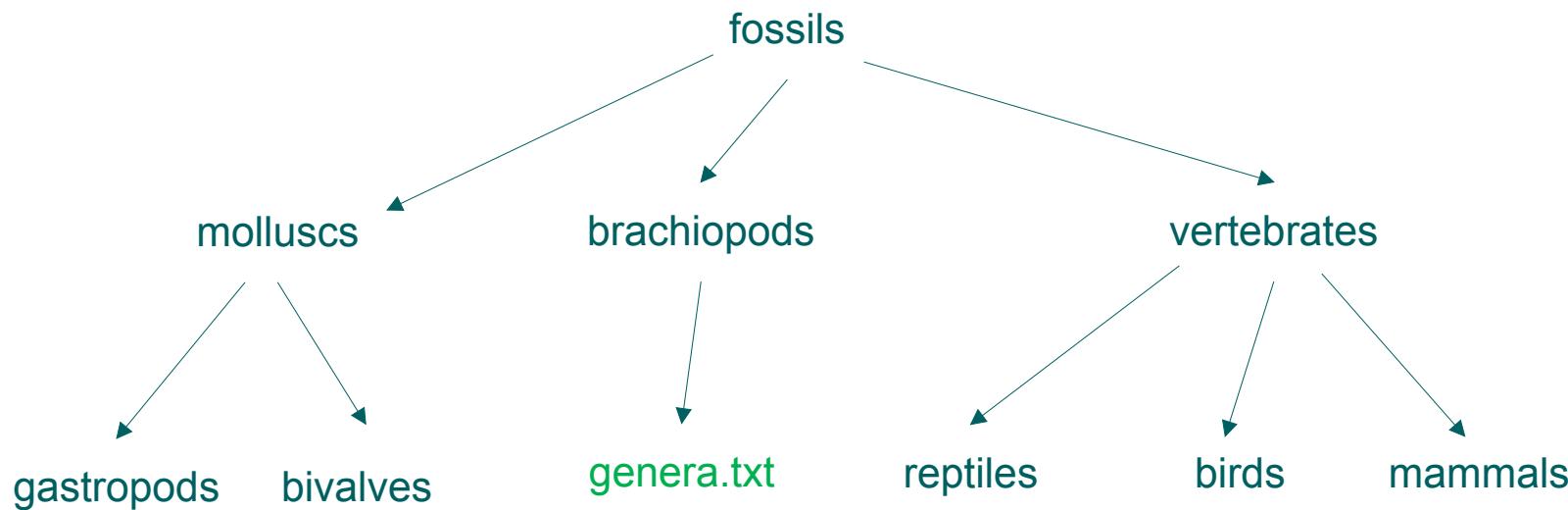


```
adam@positonia: ~ 73x30
adam@positonia:~$ cp fossil_path.txt fossils
adam@positonia:~$ ls fossils
brachiopods fossil_path.txt molluscs vertebrates
adam@positonia:~$ rm fossils/fossil_path.txt
adam@positonia:~$ ls fossils
brachiopods molluscs vertebrates
adam@positonia:~$
```

File disappeared

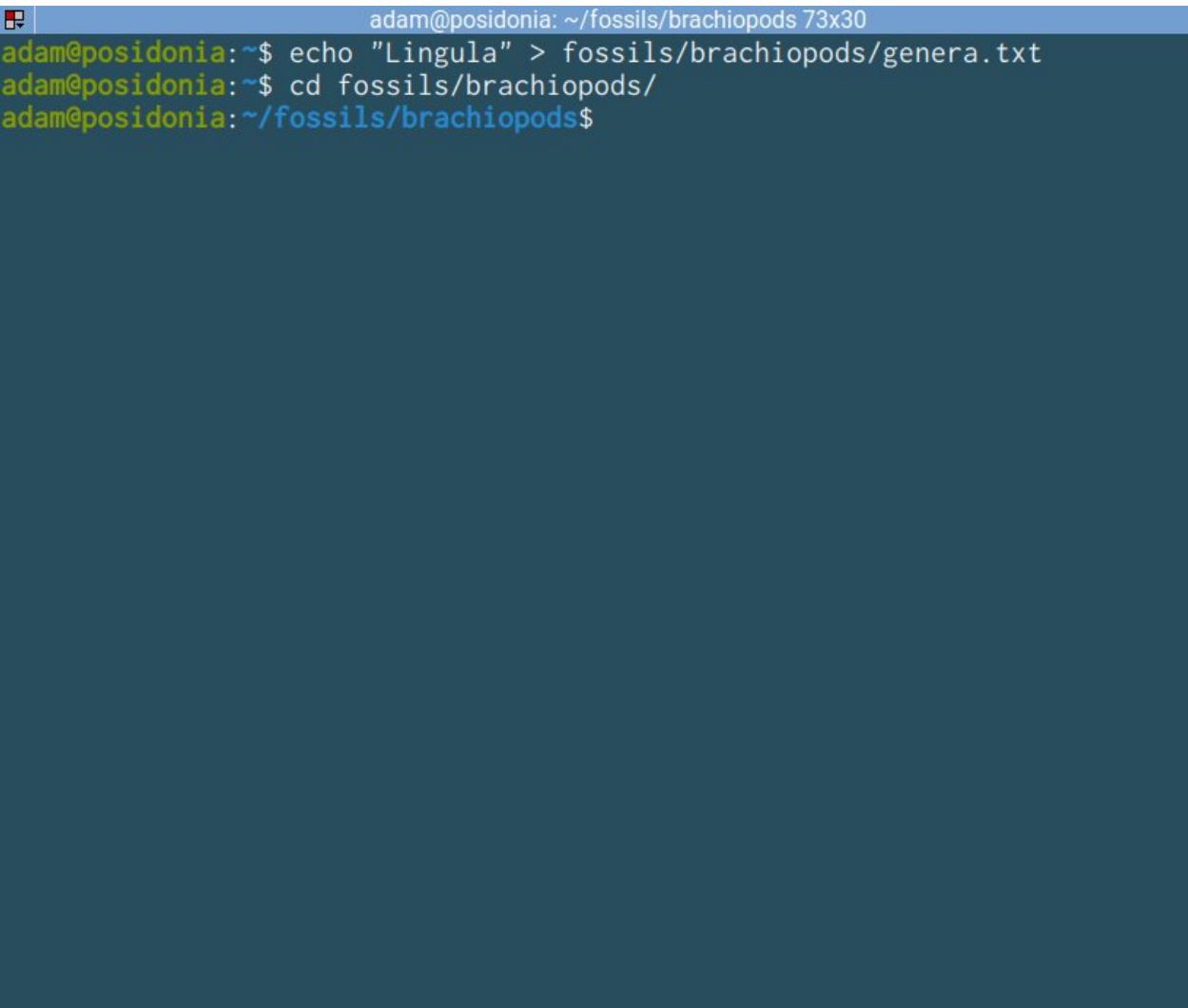
Exercise!

1. Use an echo statement to write the genus name “*Lingula*” into fossils/brachiopods/genera.txt!
2. Then change directory to brachiopods.



```
echo "Lingula" > fossils/brachiopods/genera.txt
```

- You can use the double chevron >> to append to an existing file



```
adam@positonia: ~/fossils/brachiopods 73x30
adam@positonia:~$ echo "Lingula" > fossils/brachiopods/genera.txt
adam@positonia:~$ cd fossils/brachiopods/
adam@positonia:~/fossils/brachiopods$
```

```
echo "Spiriferina" >> genera.txt
```

Appending to files

- You can use the double chevron `>>` to append to an existing file
- Added to new line!

```
adam@positron: ~/fossils/brachiopods 73x30
adam@positron:~$ echo "Lingula" > fossils/brachiopods/genera.txt
adam@positron:~$ cd fossils/brachiopods/
adam@positron:~/fossils/brachiopods$ echo "Spiriferina" >> genera.txt
adam@positron:~/fossils/brachiopods$ cat genera.txt
Lingula
Spiriferina
adam@positron:~/fossils/brachiopods$
```

Special characters

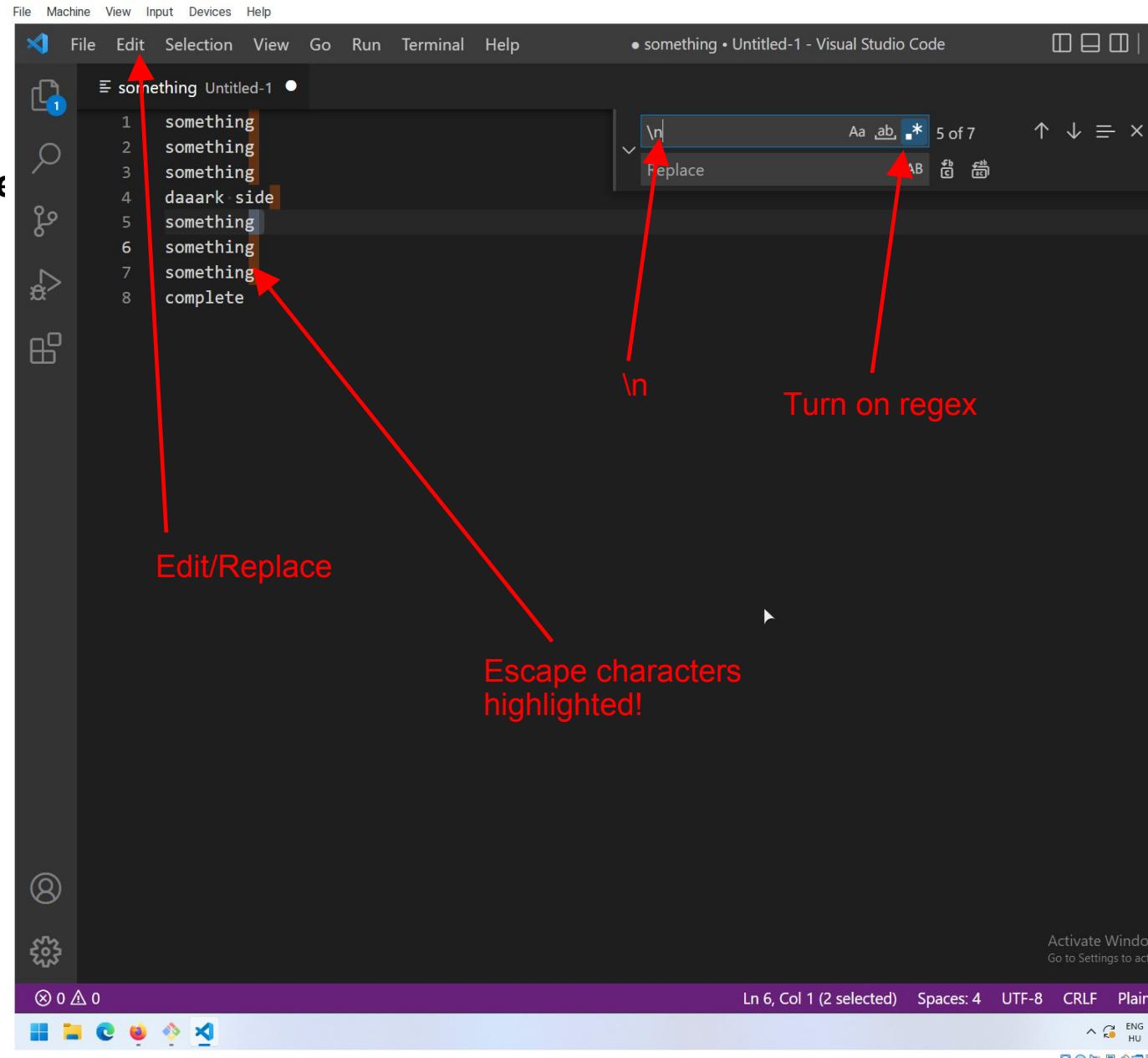
We use so called “escape characters to denote special symbols, that sometimes have other meanings.

\n: newline escape

\t : tab escape

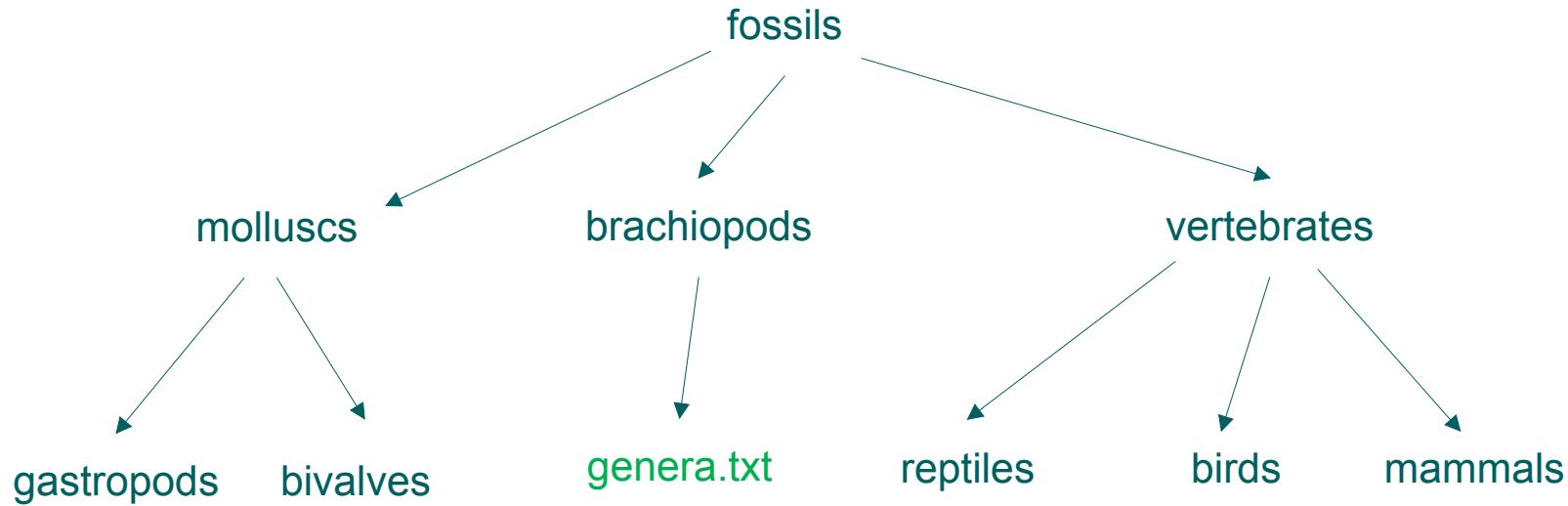
\" : double quote escape

\' : single quote escape



Exercise!

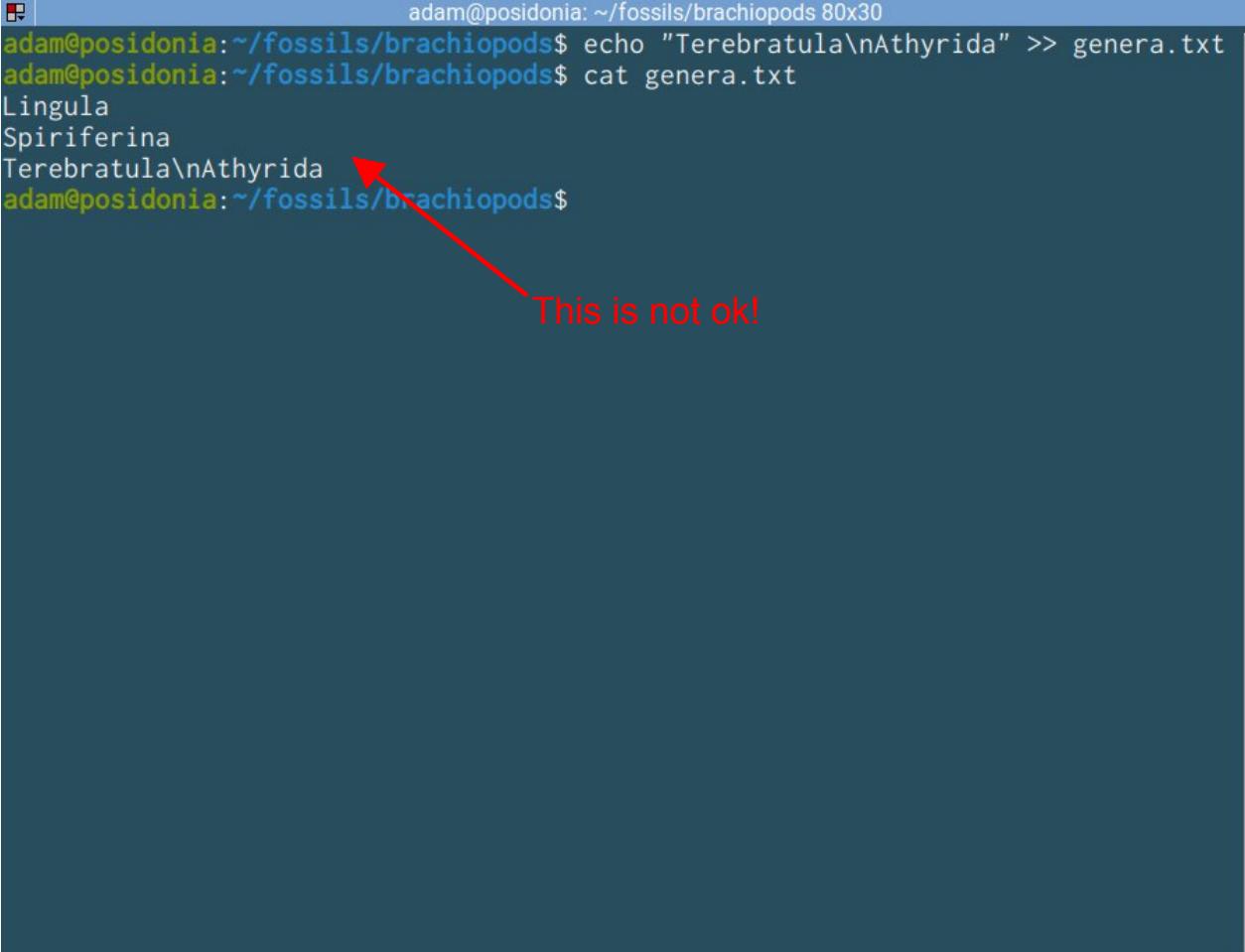
1. Use an `echo` statement to write the genus name “*Terebratula*” and “*Athyris*” into `fossils/brachiopods/genera.txt`, **use a newline escape between them!**
2. Then change directory to `brachiopods`.



```
echo "Terebratula\nAthyrida" >> genera.txt
```

Appending to files

- It doesn't seem to work!
- Echo needs to know to replace the combination `\n` with the newline character!



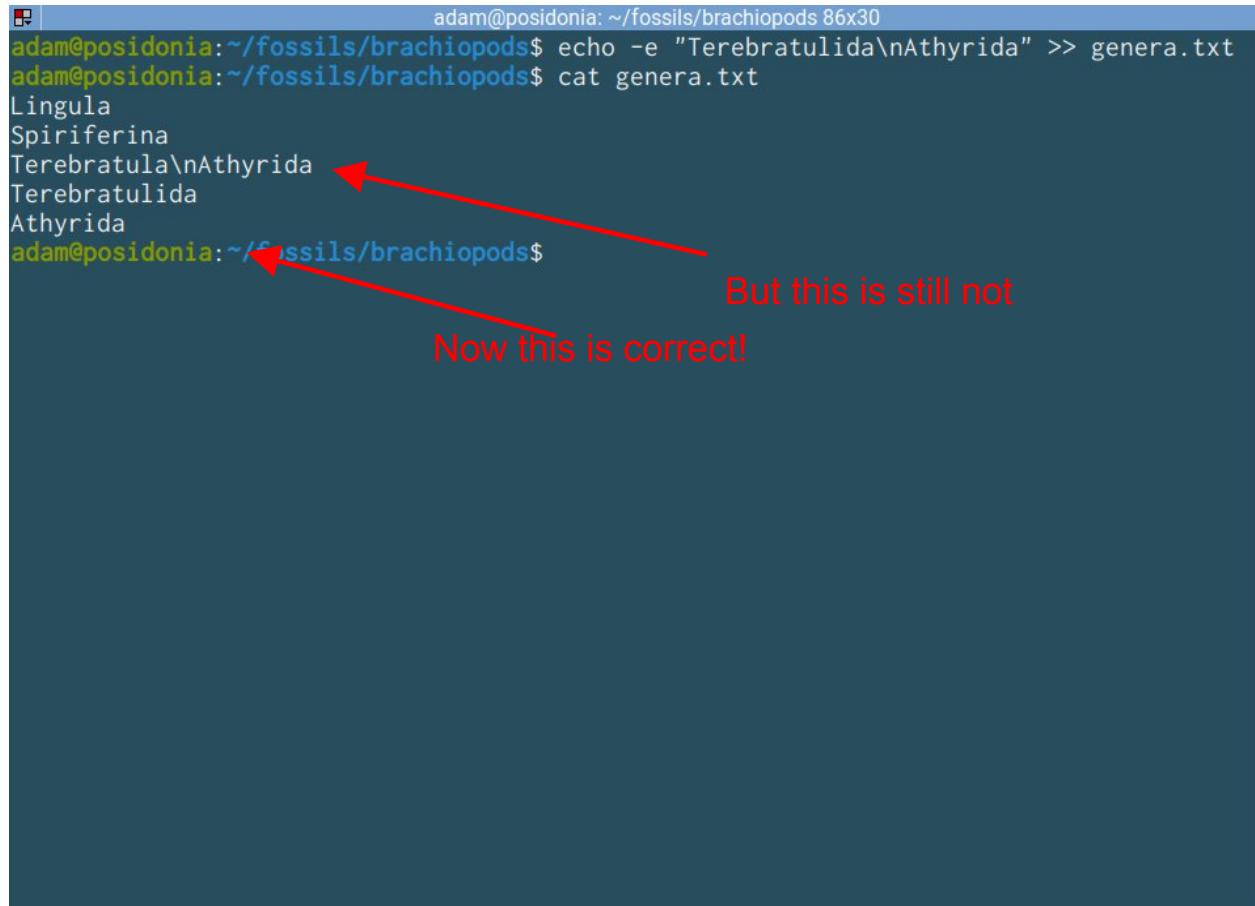
```
adam@positonia: ~/fossils/brachiopods 80x30
adam@positonia:~/fossils/brachiopods$ echo "Terebratula\nAthyrida" >> genera.txt
adam@positonia:~/fossils/brachiopods$ cat genera.txt
Lingula
Spiriferina
Terebratula\nAthyrida
adam@positonia:~/fossils/brachiopods$
```

This is not ok!

```
echo -e "Terebratula\nAthyrida" >> genera.txt
```

Appending to files

- Use the `-e` option!
- Our file is messed up. Options:
 - 1. Redo our file
 - 2. Use an editor to correct
- Delete the bad line!
- Better, next time: go back in time
e.g. use version control!



```
adam@posidonia: ~/fossils/brachiopods 86x30
adam@posidonia:~/fossils/brachiopods$ echo -e "Terebratulida\nAthyrida" >> genera.txt
adam@posidonia:~/fossils/brachiopods$ cat genera.txt
Lingula
Spiriferina
Terebratula\nAthyrida
Terebratulida
Athyrida
adam@posidonia:~/fossils/brachiopods$
```

But this is still not
Now this is correct!

Joint Exercise

- Create the directory structure here!

