Practical Computing for Scientists

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UOIT – Fall 2015

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

The Unix Shell

Creating and Deleting

Created by Greg Wilson

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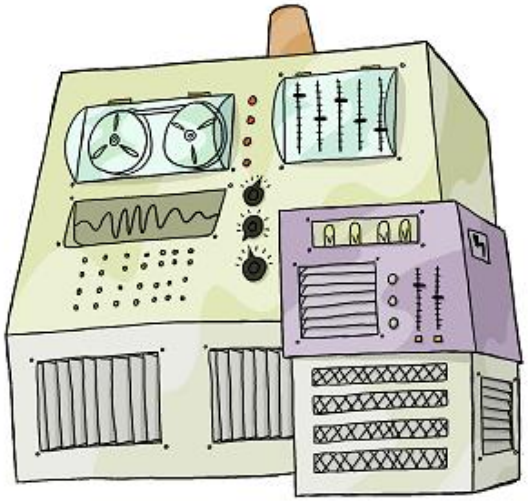
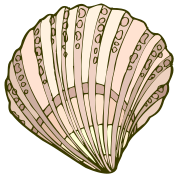
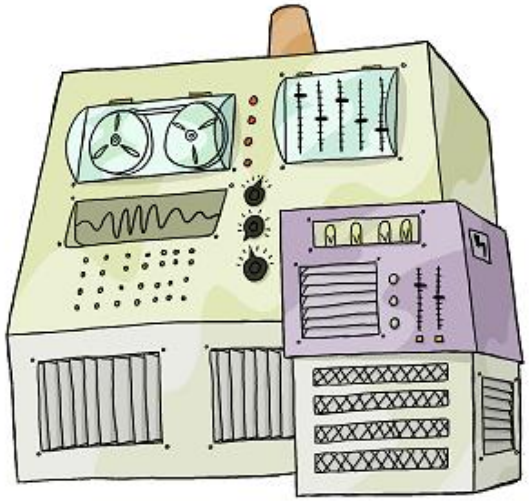
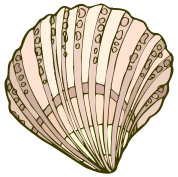




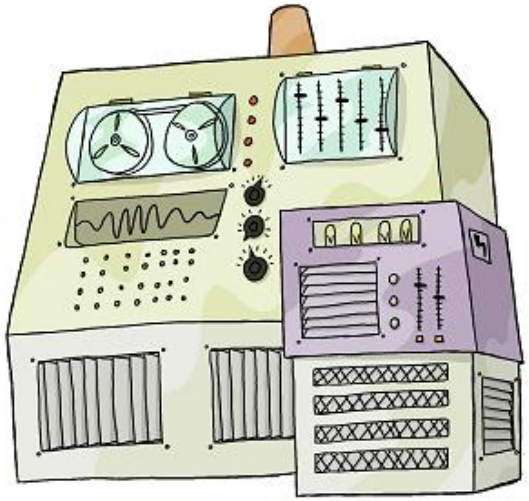
shell

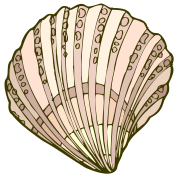




shell

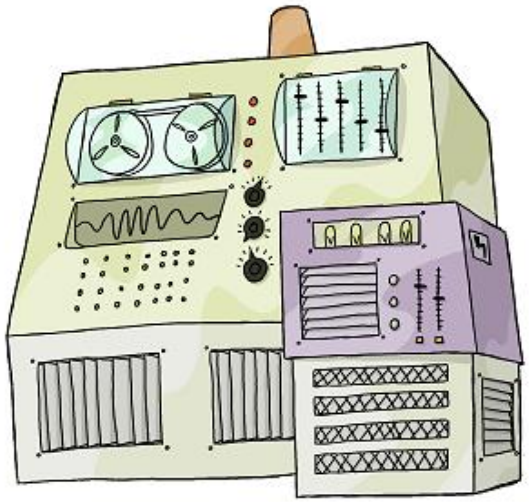
`pwd`	print working directory
`cd`	change working directory
`ls`	listing
`.`	current directory
`..`	parent directory





shell

`pwd`	print working directory
`cd`	change working directory
`ls`	listing
`.`	current directory
`..`	parent directory



But how do we create things in the first place?

```
$ pwd
/users/nelle
$
```

```
$ pwd
/users/nelle
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/
$
```

```
$ pwd
/users/nelle
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/
$ mkdir tmp
```

```
$ pwd
/users/nelle
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/
$ mkdir tmp
```

make directory

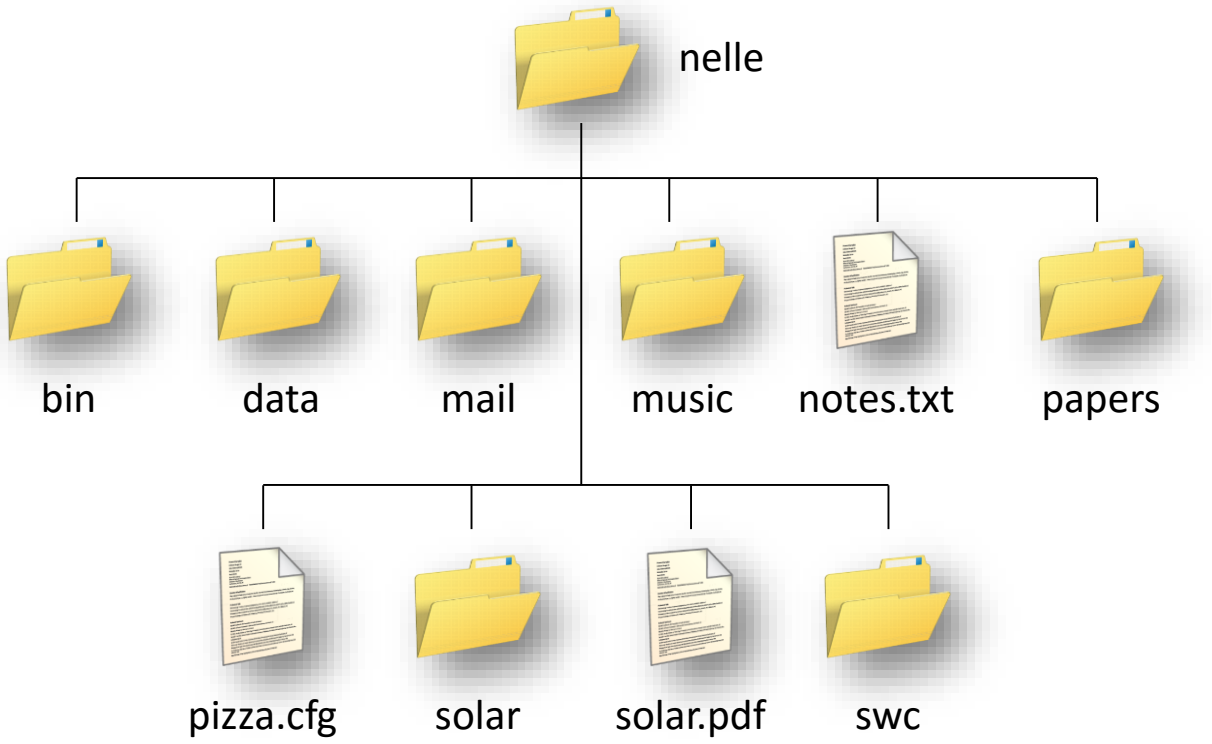
```
$ pwd
/users/nelle
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/
$ mkdir tmp
```

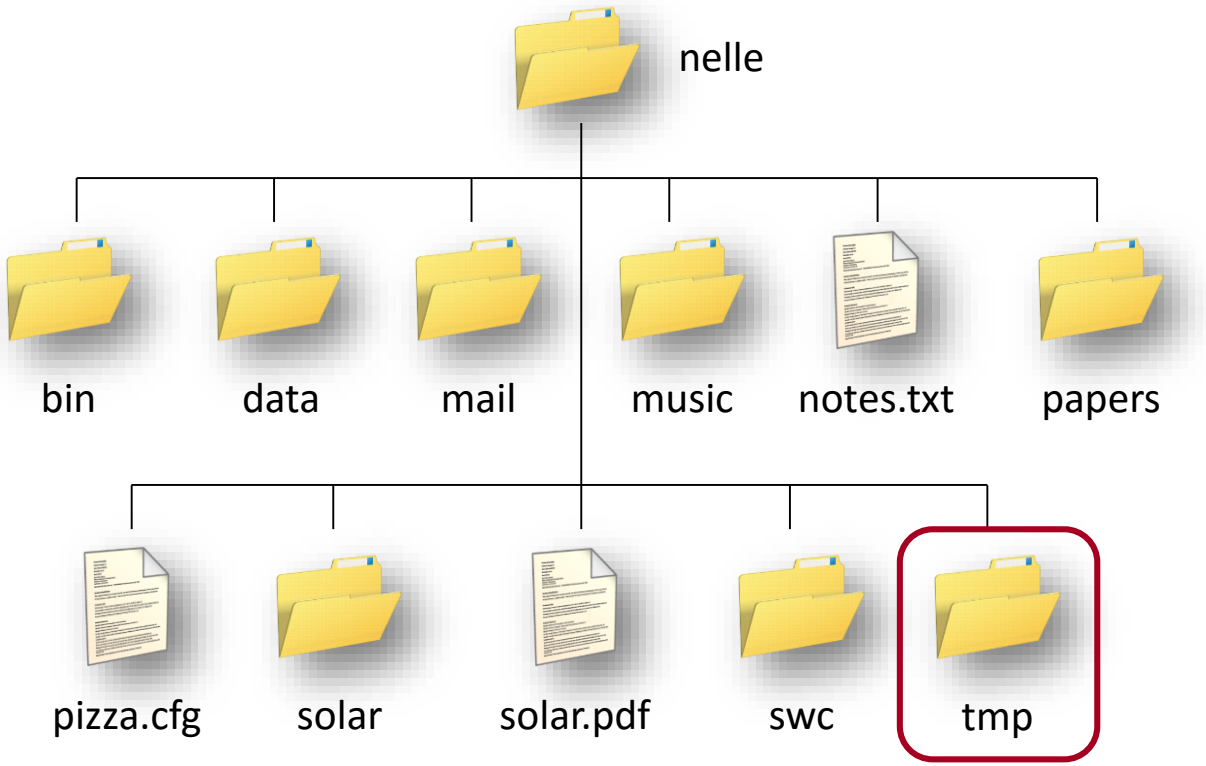
make directory

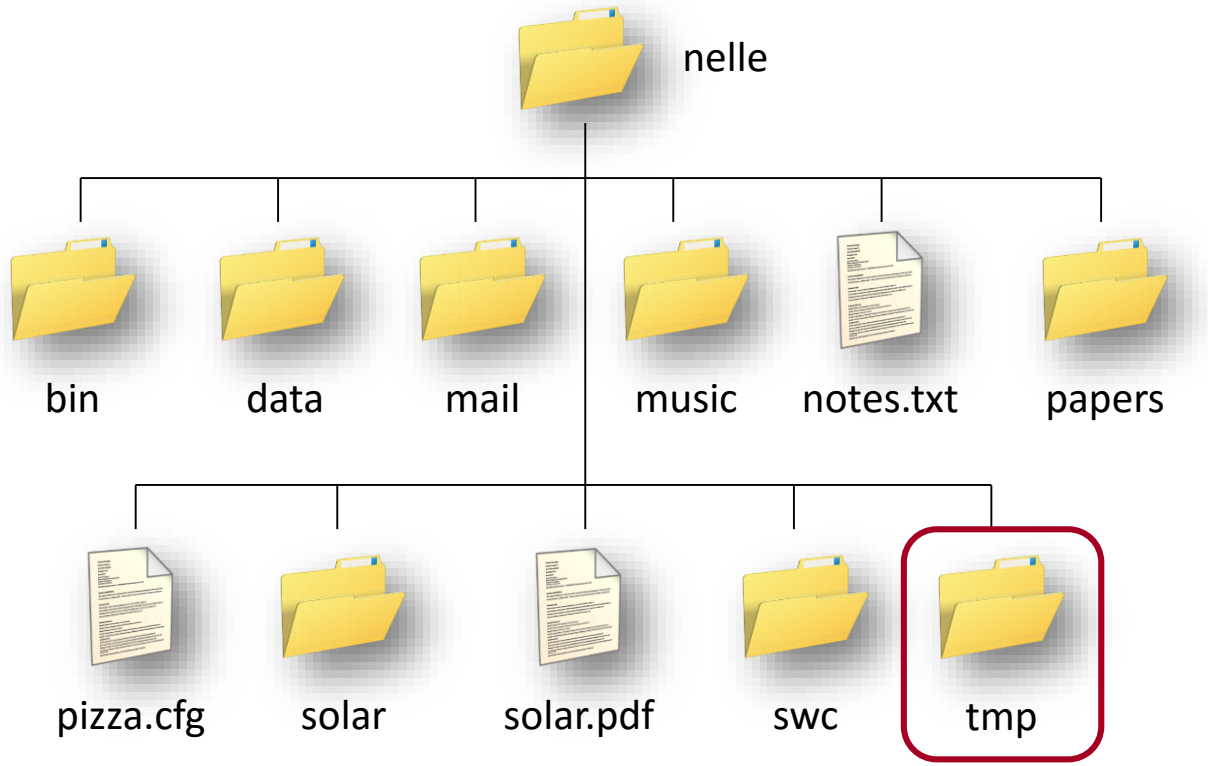
a relative path, so the new directory is made below the current one

```
$ pwd
/users/nelle
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/
$ mkdir tmp
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/      tmp/
$
```

```
$ pwd
/users/nelle
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/
$ mkdir tmp
$ ls -F
bin/          data/     mail/      music/
notes.txt     papers/   pizza.cfg  solar/
solar.pdf     swc/      tmp/
$
```


nelle
bin
data
mail
music
notes.txt
papers
pizza.cfg
solar
solar.pdf
swc


nelle
bin
data
mail
music
notes.txt
papers
pizza.cfg
solar
solar.pdf
swc
tmp



nothing below it yet

```
$ pwd
/users/nelle
$
```

```
$ pwd
/users/nelle
$ ls tmp
$
```

```
$ pwd
/users/nelle
$ ls tmp
$
```

no output

```
$ pwd
/users/nelle
$ ls tmp
$ ls -a tmp
.              ..
$
```

```
$ pwd
/users/nelle
$ ls tmp
$ ls -a tmp
.              ..
```

/users/nelle/tmp

```
$ pwd
/users/nelle
$ ls tmp
$ ls -a tmp
.                ..
```

/users/nelle

```
$ cd tmp
$ nano junk
```

```
$ cd tmp
$ nano junk
```

a text editor only a programmer could love

```
$ cd tmp
$ nano junk
```

a text editor only a programmer could love

really do mean "text"...

```
$ cd tmp
$ nano junk
```

```
GNU nano 2.0.7                          File: junk



                                      [ New File ]
^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 Text     ^T To Spell
```

```
$ cd tmp
$ nano junk
```

That's your cursor

```
GNU nano 2.0.7                          File: junk

_

                                      [ New File ]
^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 Text     ^T To Spell
```

```
$ cd tmp
$ nano junk
```

```
GNU nano 2.0.7                              File: junk

Make everything as simple as possible,
but no simpler.␣

                                          [ New File ]
^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 Text     ^T To Spell
```

```
$ cd tmp
$ nano junk
```

```
GNU nano 2.0.7                              File: junk

Make everything as simple as possible,
but no simpler.

                                            [ New File ]
^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 Text  ^T To Spell
```

^O means "Control + O" (to save changes)

```
$ cd tmp
$ nano junk
```

```
GNU nano 2.0.7                              File: junk

Make everything as simple as possible,
but no simpler.␣




                                          [ New File ]
^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 Text     ^T To Spell
```

^X to exit back to the shell

```
$ cd tmp
$ nano junk
$
```

nano doesn't leave any output on the screen after it exits

```
$ cd tmp
$ nano junk
$ ls
junk
$
```

but it has created the file

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$
```

use `-s` to show sizes

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$
```

use `-s` to show sizes reported in disk blocks

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$
```

use `-s` to show sizes
reported in disk blocks
a less helpful default
may have been possible…

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$ ls -s -h
 512  junk
$
```

use `-h` for human-friendly output

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$ ls -s -h
 512  junk
$
```

use `-h` for human-friendly output

number of bytes

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$ ls -s -h
 512  junk
$
```

use `-h` for human-friendly output

number of bytes

rounded up because computer stores things on disk using blocks of 512 bytes

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$ ls -s -h
 512  junk
$ rm junk
$
```

remove (delete) file

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$ ls -s -h
 512  junk
$ rm junk
$
```

remove (delete) file

there is no (easy) un-delete!

```
$ cd tmp
$ nano junk
$ ls
junk
$ ls -s
   1  junk
$ ls -s -h
 512  junk
$ rm junk
$ ls
$
```

← check that it's gone

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$
```

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$
```

change working directory to `/users/nelle`

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$ rm tmp
rm: cannot remove 'tmp': Is a directory
$
```

`rm` only works on files

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$ rm tmp
rm: cannot remove 'tmp': Is a directory
$ rmdir tmp
```

use `rmdir` to remove directories

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$ rm tmp
rm: cannot remove 'tmp': Is a directory
$ rmdir tmp
rmdir: failed to remove 'tmp': Directory not empty
$
```

but it only works when the directory is empty

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$ rm tmp
rm: cannot remove 'tmp': Is a directory
$ rmdir tmp
rmdir: failed to remove 'tmp': Directory not empty
$
```

but it only works when the directory is empty (safety feature)

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$ rm tmp
rm: cannot remove 'tmp': Is a directory
$ rmdir tmp
rmdir: failed to remove 'tmp': Directory not empty
$ rm tmp/junk
$
```

so get rid of the directory's contents...

```
$ pwd
/users/nelle/tmp
$ nano junk
$ ls
junk
$ cd ..
$ rm tmp
rm: cannot remove 'tmp': Is a directory
$ rmdir tmp
rmdir: failed to remove 'tmp': Directory not empty
$ rm tmp/junk
$ rmdir tmp
$
```

...then get rid of the directory

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$
```

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$
```

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$
```

move a file

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$
```

move a file (or directory)

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$
```

move a file (or directory)
from here...

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$
```

move a file (or directory)

from here...

...to here

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$
```

move a file (or directory)

from here...

...to here

renames the file!

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$
```

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$ mv tmp/quotes.txt .
$
```

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$ mv tmp/quotes.txt .
$
```

← current working directory

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$ mv tmp/quotes.txt .
$
```

Move `/users/nelle/tmp/quotes.txt` to `/users/nelle/quotes.txt`

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$ mv tmp/quotes.txt .
$ ls tmp
$
```

nothing left in `tmp`

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$ mv tmp/quotes.txt .
$ ls tmp
$ ls quotes.txt
quotes.txt
```

← `quotes.txt` now in this directory

```
$ pwd
/users/nelle/tmp
$ mkdir tmp
$ nano tmp/junk
$ ls tmp
junk
$ mv tmp/junk tmp/quotes.txt
$ ls tmp
quotes.txt
$ mv tmp/quotes.txt .
$ ls tmp
$ ls quotes.txt
quotes.txt
```

`ls` with a file or directory argument lists that file or directory

```
$ cp quotes.txt tmp/quotations.txt
$
```

copy a file

```
$ cp quotes.txt tmp/quotations.txt
$ ls quotes.txt tmp/quotations.txt
quotes.txt   tmp/quotations.txt
$
```

```
$ cp quotes.txt tmp/quotations.txt
$ ls quotes.txt tmp/quotations.txt
quotes.txt   tmp/quotations.txt
$ rm quotes.txt
$
```

```
$ cp quotes.txt tmp/quotations.txt
$ ls quotes.txt tmp/quotations.txt
quotes.txt   tmp/quotations.txt
$ rm quotes.txt
$ ls quotes.txt tmp/quotations.txt
ls: cannot access quotes.txt: No such file or directory
tmp/quotations.txt
$
```

```
$ cp quotes.txt tmp/quotations.txt
$ ls quotes.txt tmp/quotations.txt
quotes.txt   tmp/quotations.txt
$ rm quotes.txt
$ ls quotes.txt tmp/quotations.txt
ls: cannot access quotes.txt: No such file or directory
tmp/quotations.txt
$ cp tmp/quotations.txt .
$ ls quotations.txt
quotations.txt
$
```

```
$ cp quotes.txt tmp/quotations.txt
$ ls quotes.txt tmp/quotations.txt
quotes.txt   tmp/quotations.txt
$ rm quotes.txt
$ ls quotes.txt tmp/quotations.txt
ls: cannot access quotes.txt: No such file or directory
tmp/quotations.txt
$ cp tmp/quotations.txt .
$ ls quotations.txt
quotations.txt
$
```

this is a directory, so the copy has the same name as the original file

`pwd`	print working directory
`cd`	change working directory
`ls`	listing
`.`	current directory
`..`	parent directory
`mkdir`	make a directory
`nano`	text editor
`rm`	remove (delete) a file
`rmdir`	remove (delete) a directory
`mv`	move (rename) a file or directory
`cp`	copy a file

Checkpoint 3

- Please complete the *What is Reality Survey Results*:
  - Blackboard > Course Content > Week 2 (Sept. 21-25) > Monday Sept. 21 > Checkpoint 3

The Unix Shell

Pipes and Filters

Created by Greg Wilson

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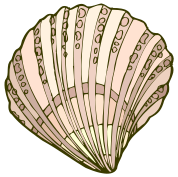
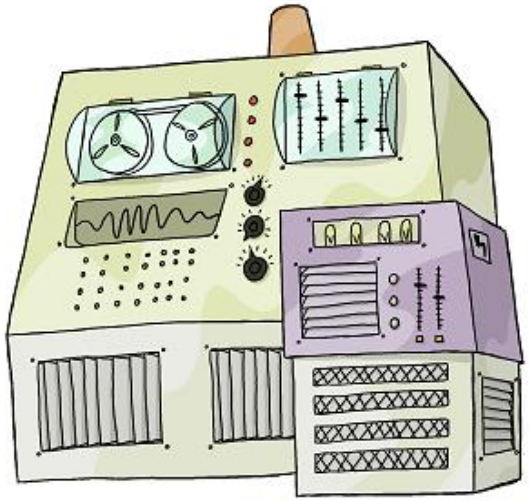
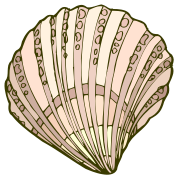


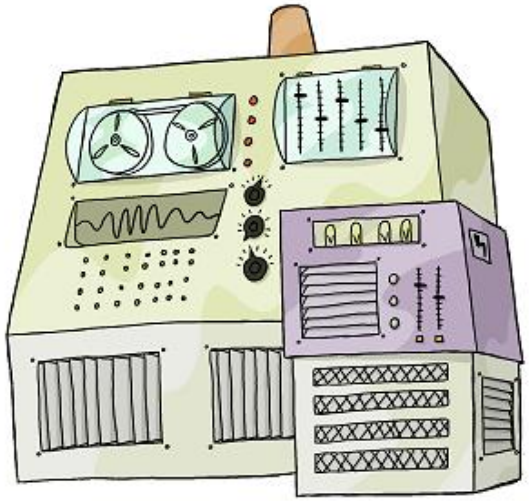
shell

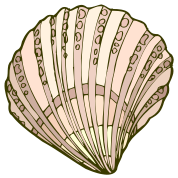




shell

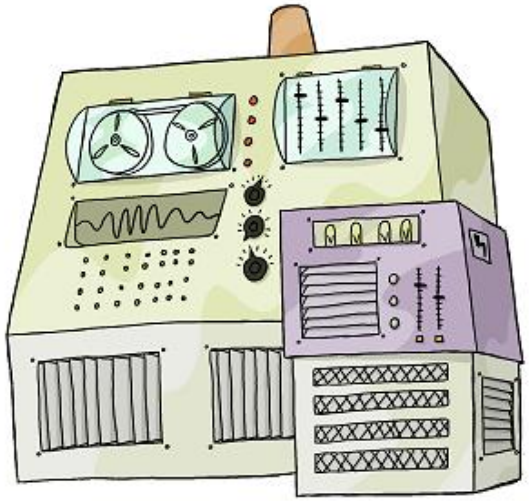
pwd	mkdir
cd	nano
ls	rm
.	rmdir
..	mv
	cp





shell

`pwd`	`mkdir`
`cd`	`nano`
`ls`	`rm`
`.`	`rmdir`
`..`	`mv`
	`cp`



More powerful

when combined

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$
```

```
$ ls molecules
cubane.pdb    ethane.pdb    methane.pdb
octane.pdb    pentane.pdb   propane.pdb
$ cd molecules
$
```

```
$ ls molecules
cubane.pdb    ethane.pdb    methane.pdb
octane.pdb    pentane.pdb   propane.pdb
$ cd molecules
$ wc *.pdb
```

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
```

* is a *wild card*

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
```

* is a *wild card*

matches zero or more characters

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
```

* is a *wild card*

matches zero or more characters

so *.pdb matches all filenames

ending in .pdb

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
```

```
wc cubane.pdb ethane.pdb methane.pdb octane.pdb pentane.pdb propane.pdb
```

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
```

word count

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
```

word count

counts lines, words, and characters in files

```
$ ls molecules
cubane.pdb     ethane.pdb     methane.pdb
octane.pdb     pentane.pdb    propane.pdb
$ cd molecules
$ wc *.pdb
  20  156 1158 cubane.pdb
  12   84  622 ethane.pdb
   9   57  422 methane.pdb
  30  246 1828 octane.pdb
  21  165 1226 pentane.pdb
  15  111  825 propane.pdb
 107  819 6081 total
$
```

```
$ wc -l *.pdb
  20  cubane.pdb
  12  ethane.pdb
   9  methane.pdb
  30  octane.pdb
  21  pentane.pdb
  15  propane.pdb
 107  total
$
```

report only lines

```
$ wc -l *.pdb
  20  cubane.pdb
  12  ethane.pdb
   9  methane.pdb
  30  octane.pdb
  21  pentane.pdb
  15  propane.pdb
 107  total
$
```

report only lines

use -w for words or

-c for characters

```
 20  cubane.pdb
 12  ethane.pdb
  9  methane.pdb
 30  octane.pdb
 21  pentane.pdb
 15  propane.pdb
107  total
```

Which file is shortest?

```
 20  cubane.pdb
 12  ethane.pdb
  9  methane.pdb
 30  octane.pdb
 21  pentane.pdb
 15  propane.pdb
107  total
```

Which file is shortest?

Easy to see when there are six…

```
 20  cubane.pdb
 12  ethane.pdb
  9  methane.pdb
 30  octane.pdb
 21  pentane.pdb
 15  propane.pdb
107  total
```

Which file is shortest?

Easy to see when there are six…

…but what if there were 6000?

```
$ wc -l *.pdb > lengths
$
```

```
$ wc -l *.pdb > lengths
$
```

redirect output to a file

```
$ wc -l *.pdb > lengths
$
```

redirect output to a file

create file if it doesn't exist

```
$ wc -l *.pdb > lengths
$
```

redirect output to a file

create file if it doesn't exist

overwrite it if it does

```
$ wc -l *.pdb > lengths
$
```

no screen output

```
$ wc -l *.pdb > lengths
$ ls lengths
lengths
$
```

```
$ wc -l *.pdb > lengths
$ ls lengths
lengths
$ cat lengths
  20  cubane.pdb
  12  ethane.pdb
   9  methane.pdb
  30  octane.pdb
  21  pentane.pdb
  15  propane.pdb
 107  total
$
```

```
$ wc -l *.pdb > lengths
$ ls lengths
lengths
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  20  cubane.pdb
  12  ethane.pdb
   9  methane.pdb
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  21  pentane.pdb
  15  propane.pdb
 107  total
$
```

concatenate files

```
$ wc -l *.pdb > lengths
$ ls lengths
lengths
$ cat lengths
  20  cubane.pdb
  12  ethane.pdb
   9  methane.pdb
  30  octane.pdb
  21  pentane.pdb
  15  propane.pdb
 107  total
$
```

concatenate files

in this case, only one

so file contents printed to screen

```
$ sort lengths
  9  methane.pdb
 12  ethane.pdb
 15  propane.pdb
 20  cubane.pdb
 21  pentane.pdb
 30  octane.pdb
107  total
$
```

```
$ sort lengths > sorted-lengths
$
```

```
$ sort lengths > sorted-lengths
$ head -1 sorted-lengths
  9  methane.pdb
$
```

```
$ sort lengths > sorted-lengths
$ head -1 sorted-lengths
  9  methane.pdb
$
```

get the first line of the file

```
$ sort lengths > sorted-lengths
$ head -1 sorted-lengths
  9  methane.pdb
$
```

get the first line of the file
this must be the PDB file
with the fewest lines,
since sorted-lengths holds
files and line counts in
order from least to greatest

```
$ sort lengths > sorted-lengths
$ head -1 sorted-lengths
  9  methane.pdb
$
```

get the first line of the file

this must be the PDB file with the fewest lines, since sorted-lengths holds files and line counts in order from least to greatest

not particularly obvious

```
$ sort lengths | head -1
  9  methane.pdb
$
```

```
$ sort lengths | head -1
  9  methane.pdb
$
```

a *pipe*

```
$ sort lengths | head -1
  9  methane.pdb
$
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a *pipe*

use output of left side

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$ sort lengths | head -1
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use output of left side

as input to right side

```
$ sort lengths | head -1
  9  methane.pdb
$
```

a *pipe*

use output of left side

as input to right side

without creating temporary file

```
$ wc -l *.pdb | sort | head -1
  9  methane.pdb
$
```

don't need to create lengths file

```
$ wc -l *.pdb | sort | head -1
  9  methane.pdb
$
```

This simple idea is why Unix has been so successful

```
$ wc -l *.pdb | sort | head -1
  9  methane.pdb
$
```

This simple idea is why Unix has been so successful

Create simple tools that:

```
$ wc -l *.pdb | sort | head -1
  9  methane.pdb
$
```

This simple idea is why Unix has been so successful

Create simple tools that:

– do one job well

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$ wc -l *.pdb | sort | head -1
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This simple idea is why Unix has been so successful

Create simple tools that:

– do one job well

– work well with each other

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$ wc -l *.pdb | sort | head -1
  9  methane.pdb
$
```

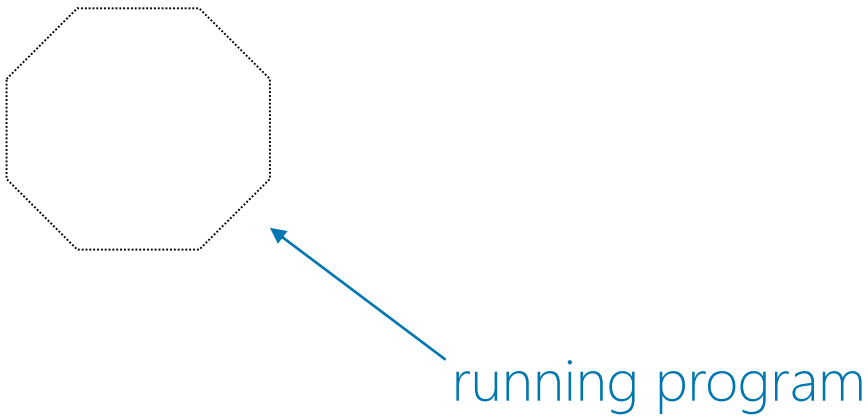
This simple idea is why Unix has been so successful

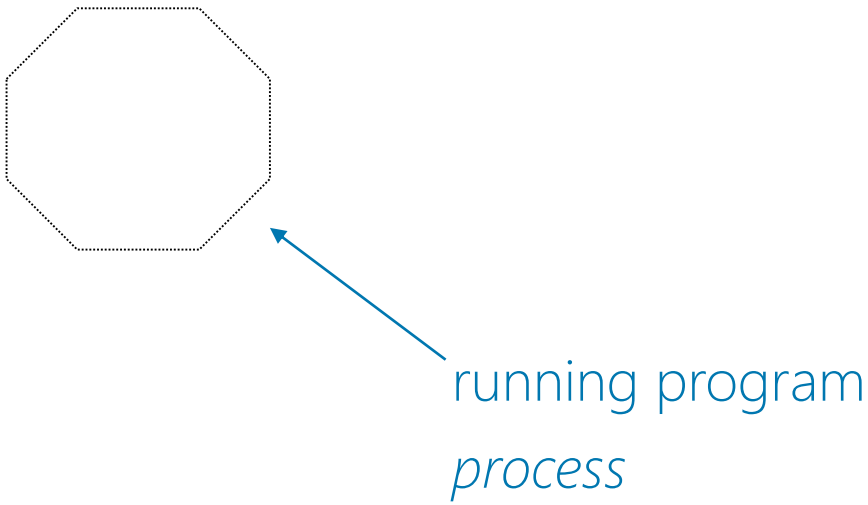
Create simple tools that:

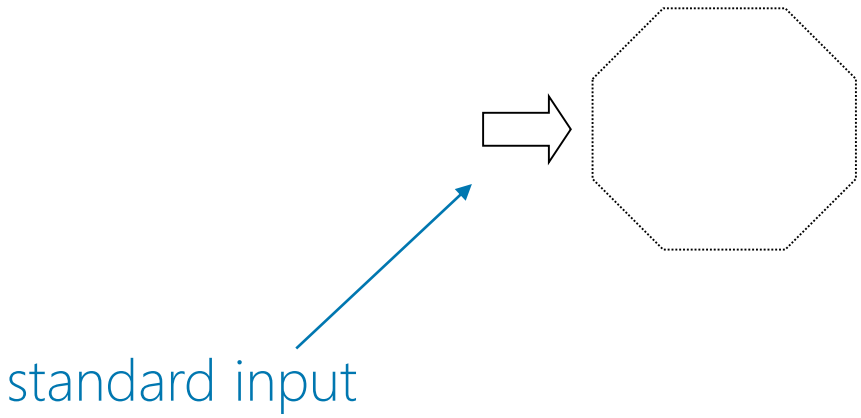
– do one job well

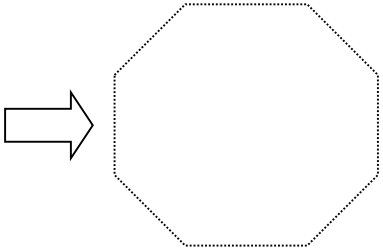
– work well with each other

10 tools can be combined in 100 ways


running program

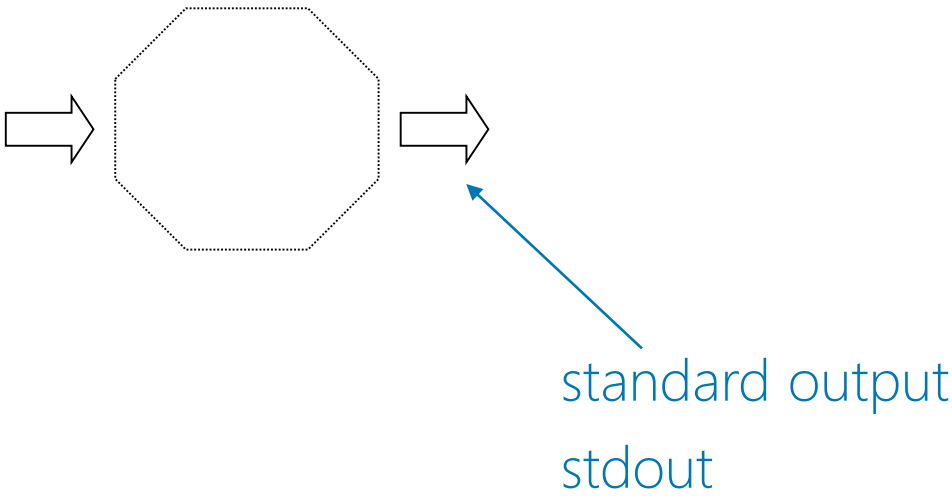

running program
process

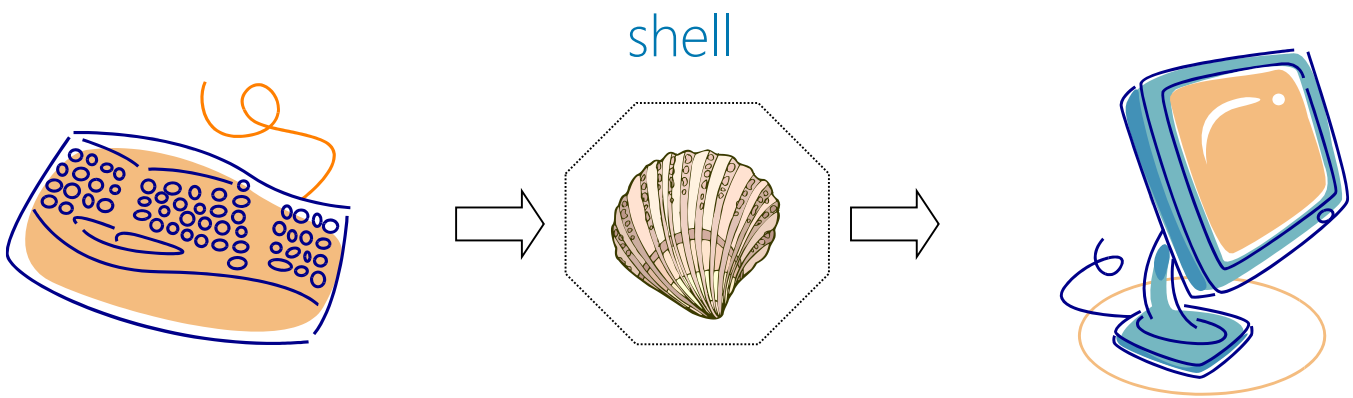

standard input

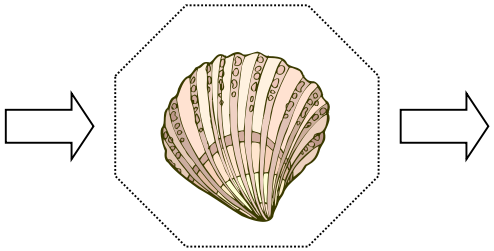


standard input

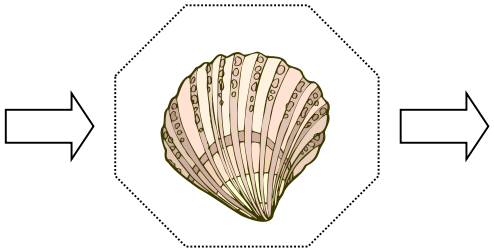
stdin


standard output
stdout

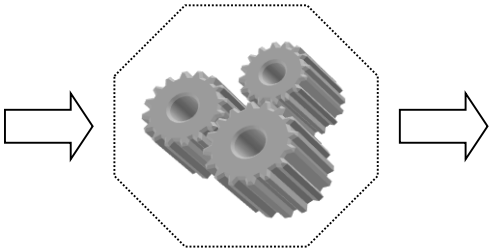

shell



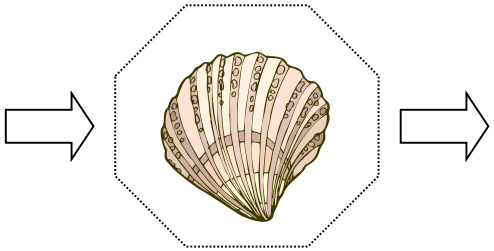
```
$ wc -l *.pdb > lengths
```



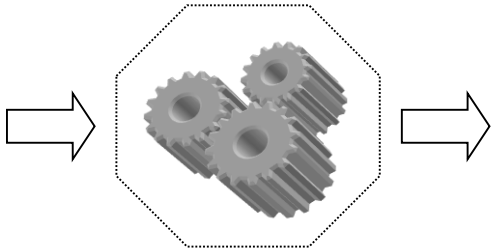
wc



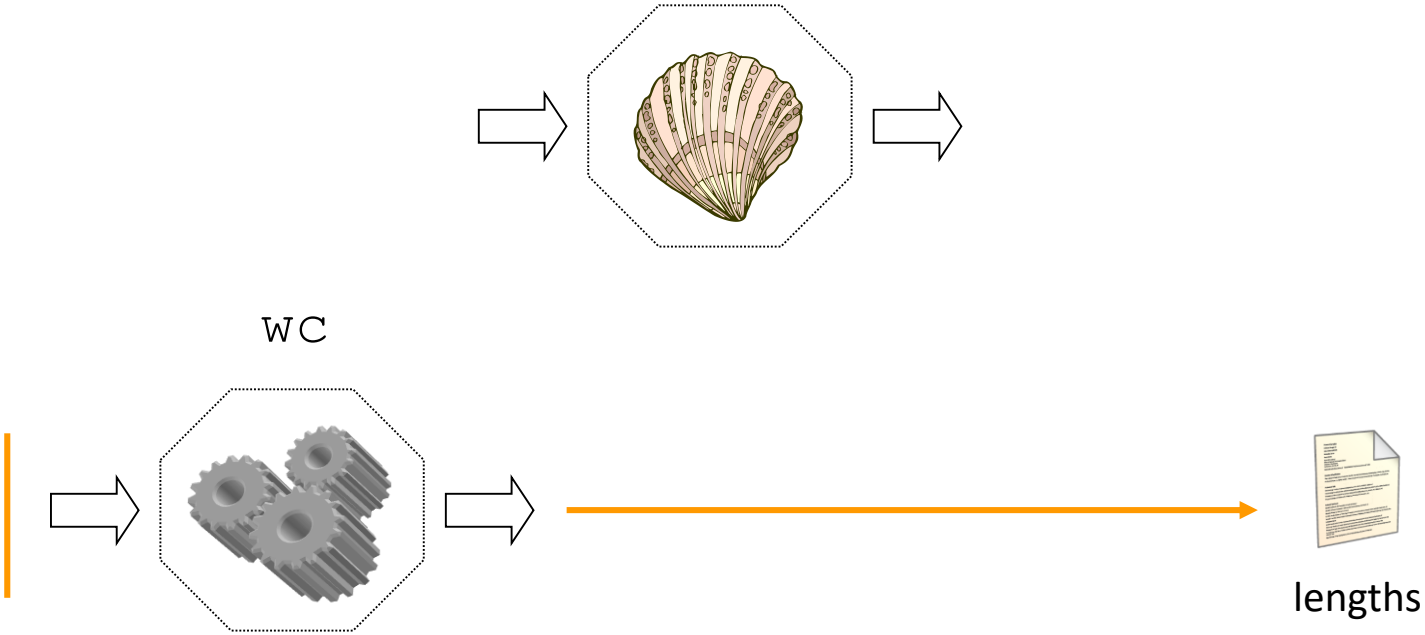
```
$ wc -l *.pdb > lengths
```



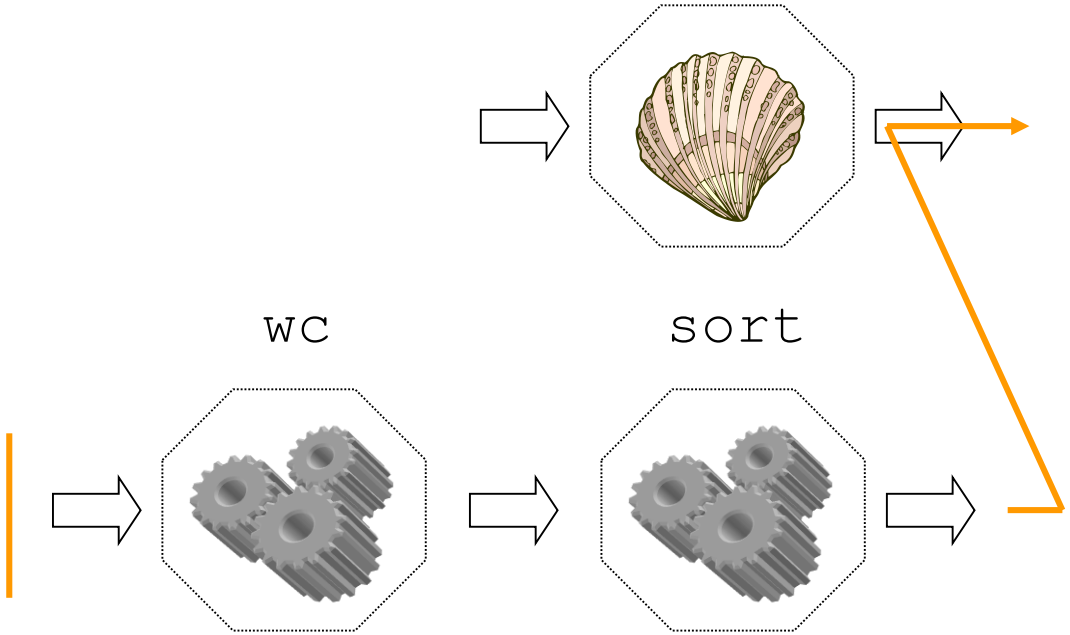
wc



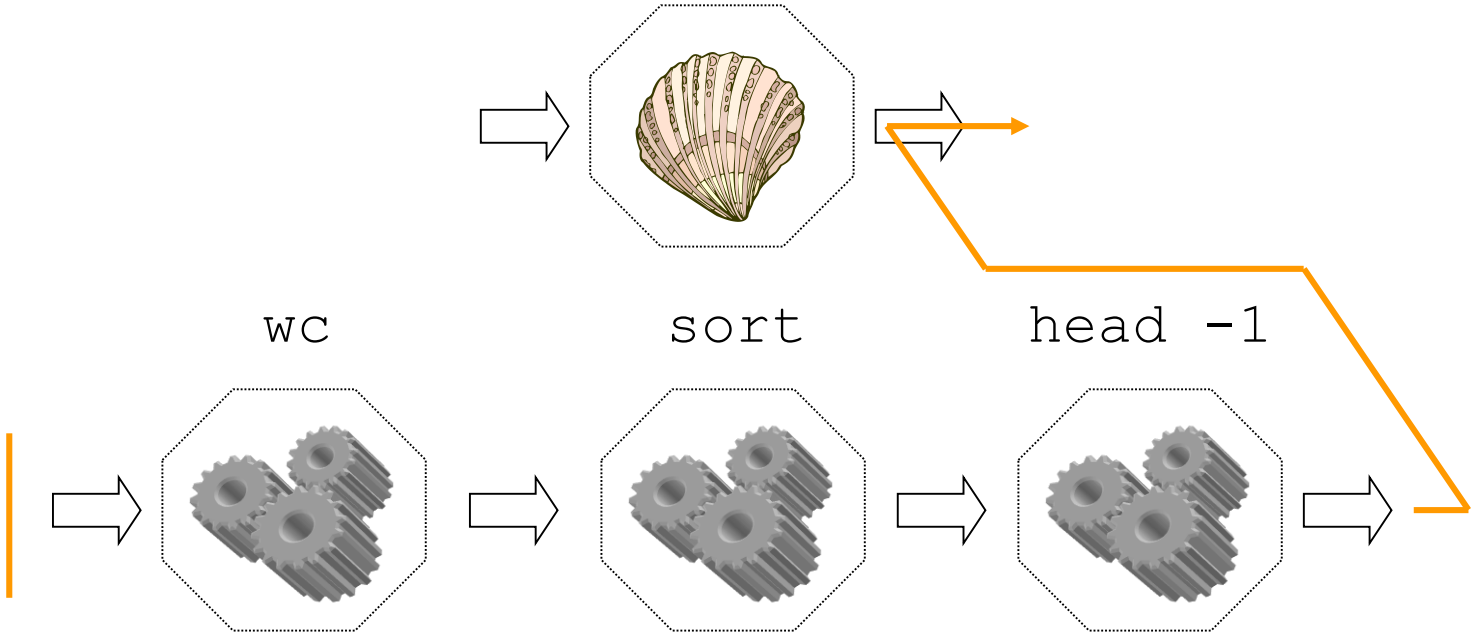
```
$ wc -l *.pdb > lengths
```




```
$ wc -l *.pdb > lengths
```




```
$ wc -l *.pdb | sort
```




```
$ wc -l *.pdb | sort | head -1
```

This programming model called *pipes and filters*

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A *filter* transforms a stream of input into a stream of output

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Any program that reads lines of text from standard input, and writes lines of text to standard output, can work with every other

You can (and should) write such programs

`pwd`	`mkdir`
`cd`	`nano`
`ls`	`rm`
`.`	`rmdir`
`..`	`mv`
	`cp`

pwd	mkdir	wc
cd	nano	sort
ls	rm	head
.	rmdir	
..	mv	
	cp	

pwd	mkdir	wc
cd	nano	sort
ls	rm	head
.	rmdir	*tail*
..	mv	*split*
	cp	*cut*
		uniq

pwd	mkdir	wc	*
cd	nano	sort	>
ls	rm	head	|
.	rmdir	*tail*	
..	mv	*split*	
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		uniq	

pwd	mkdir	wc	*
cd	nano	sort	>
ls	rm	head	|
.	rmdir	*tail*	<
..	mv	*split*	?
	cp	*cut*	
		uniq	