CS395T: Introduction to Scientific and Technical Computing

Instructors:

Dr. Karl W. Schulz, Research Associate, TACC

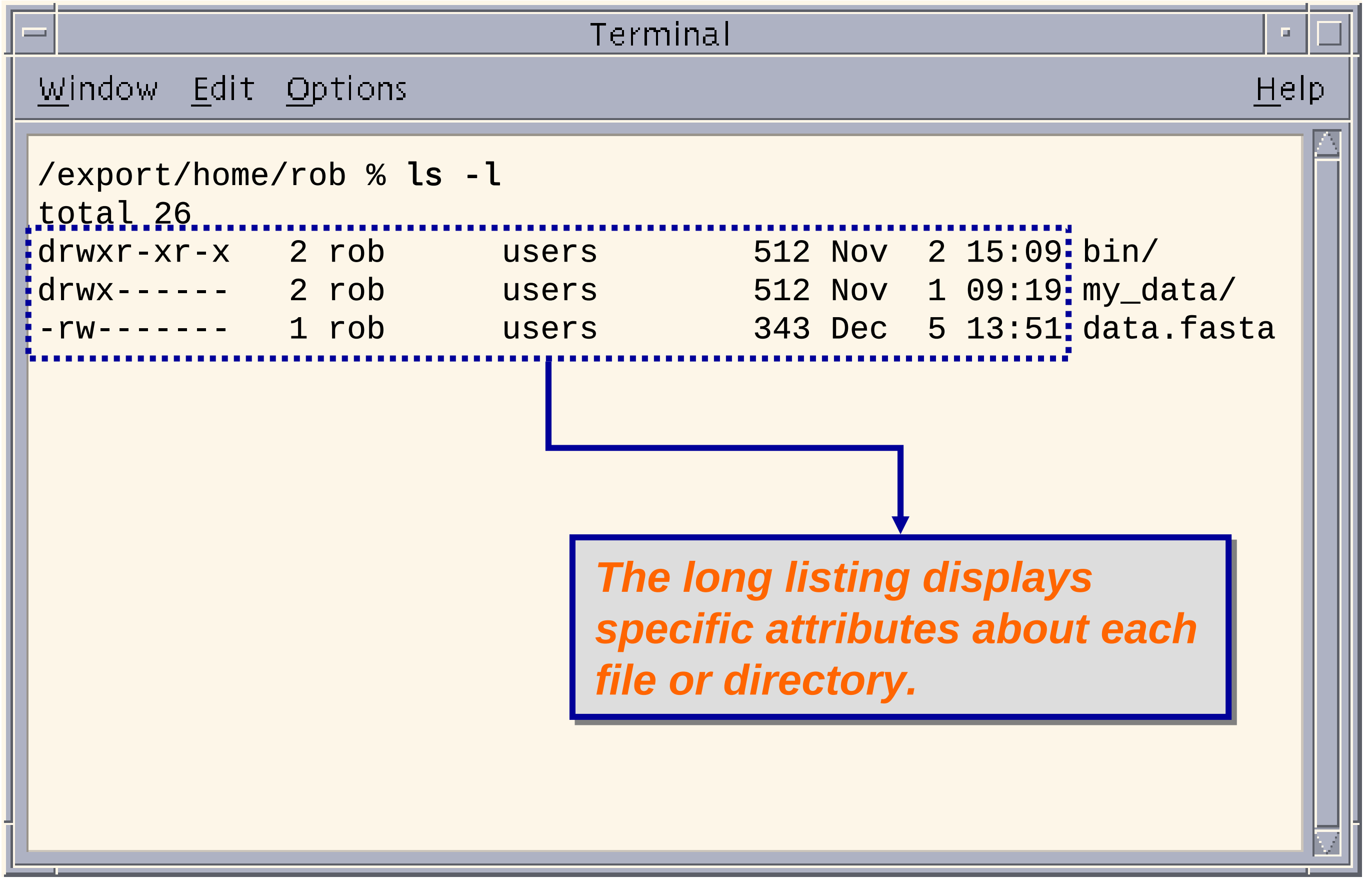
Dr. Bill Barth, Research Associate, TACC

Outline

- Continue with Unix overview
  - File attributes and permissions
  - Basic commands
  - Pattern matching, regular expressions
  - Shell scripting

UNIX Command Examples

Remember the “ls –l” command to show long listings?



```
/export/home/rob % ls -l
total 26
drwxr-xr-x   2 rob       users         512 Nov  2 15:09 bin/
drwx------   2 rob       users         512 Nov  1 09:19 my_data/
-rw-------   1 rob       users         343 Dec  5 13:51 data.fasta
```

The long listing displays specific attributes about each file or directory.

File Attributes

- Every file has a specific list of attributes:
  - Access Times:
    - when the file was created
    - when the file was last changed
    - when the file was last read
  - Size
  - Owners
    - user (*remember UID*)
    - group (*remember GID*)
  - Permissions

File Time Attributes

- Time Attributes:
  - ls -l shows when the file was last changed
  - ls -lc shows when the file was created
  - ls -lu shows when the file was last accessed

- Special names exist for these date-related attributes:
  - mtime (last modification time)
  - ctime (last change time, ie. when changes were made to the file or directory's inode: owner, permissions, etc.
  - atime (last access time)

File Permissions

- Each file has a set of permissions that control who can *access* the file
- There are three different types of permissions:
  - read abbreviated *r*
  - write abbreviated *w*
  - execute abbreviated *x*
- In Unix, there are permission levels associated with three types of people that might access a file:
  - owner (you)
  - group (a group of other users that you set up)
  - world (anyone else browsing around on the file system)

File Permissions Display Format

-rwxrwxrwx

Owner **Group** **Others**

The first entry specifies the type of file:
“-” is a plain file
“d” is a directory
“c” is a character device
“b” is a block device
“l” is a symbolic link

What is this *rwx* Craziness?

- Meaning for Files:
  - `r` - allowed to read
  - `w` - allowed to write
  - `x` - allowed to execute
- Meaning for Directories:
  - `r` - allowed to see the names of the files
  - `w` - allowed to add and remove files
  - `x` - allowed to enter the directory

Changing File Permissions

- The **chmod** command changes the permissions associated with a file or directory
- Basic syntax is: **chmod mode file**
- The *mode* can be specified in two ways:
  - symbolic representation
  - octal number
- Both methods achieve the same result (*user's choice)*
- Multiple symbolic operations can be given, separated by commas

chmod: Symbolic Representation

- *Symbolic* Mode representation has the following form:

[ugoa][+-=][rwxX…]

u=user	**+ add permission**	**r=read**
g=group	**- remove permission**	**w=write**
o=other	**= set permission**	**x=execute**
a = all		X= *pure unix gold*

- The **X** permission option is very handy - it sets to execute only if the file is a directory or already has execute permission

chmod Symbolic Mode Examples

```
> ls -al foo
-rw-------  1 karl support ...

> chmod g=rw foo
> ls -al foo
-rw-rw----  1 karl support ...

> chmod u-w,g+x,o=x foo
> ls -al foo
-r--rwx--x  1 karl support ...
```

chmod: Octal Representation

- Octal Mode uses a single argument string which describes the permissions for a file (3 digits)

- Each digit of this number is a code for each of the three permission levels (user,group,world)

- Permissions are set according to the following numbers:
  - Read = 4
  - Write = 2
  - Execute = 1

0 = no permissions whatsoever;
1 = execute only
2 = write only
3 = write and execute (1+2)
4 = read only
5 = read and execute (4+1)
6 = read and write (4+2)
7 = read and write and execute (4+2+1)

- Sum the individual permissions to get the desired combination

chmod Octal Mode Examples

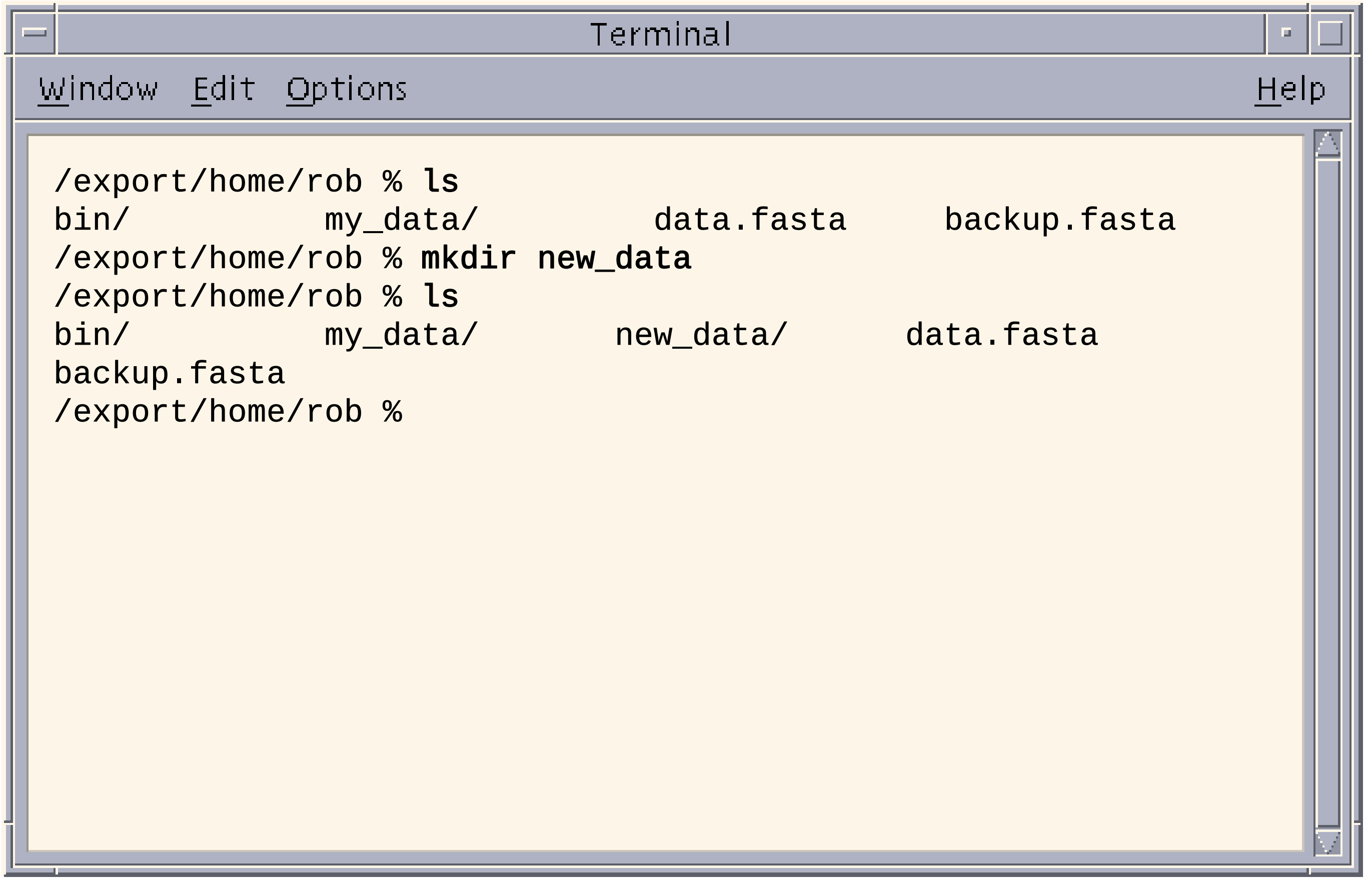
```
> ls -al foo
-rw-------  1 karl support ...

> chmod 660 foo
> ls -al foo
-rw-rw----  1 karl support ...

> chmod 417 foo
> ls -al foo
-r----xrwx  1 karl support ...
```

Basic Commands

- Some basic commands for interacting with the Unix file system are:
  - ls
  - cd
  - df
  - cat
  - more (less)
  - head
  - pwd
  - cp
  - awk
  - rm
  - chmod
  - tail
  - touch
  - mkdir
  - rmdir
  - find
  - grep
  - chown/chgrp
- Let’s cruise through some examples....

UNIX Commands: mkdir

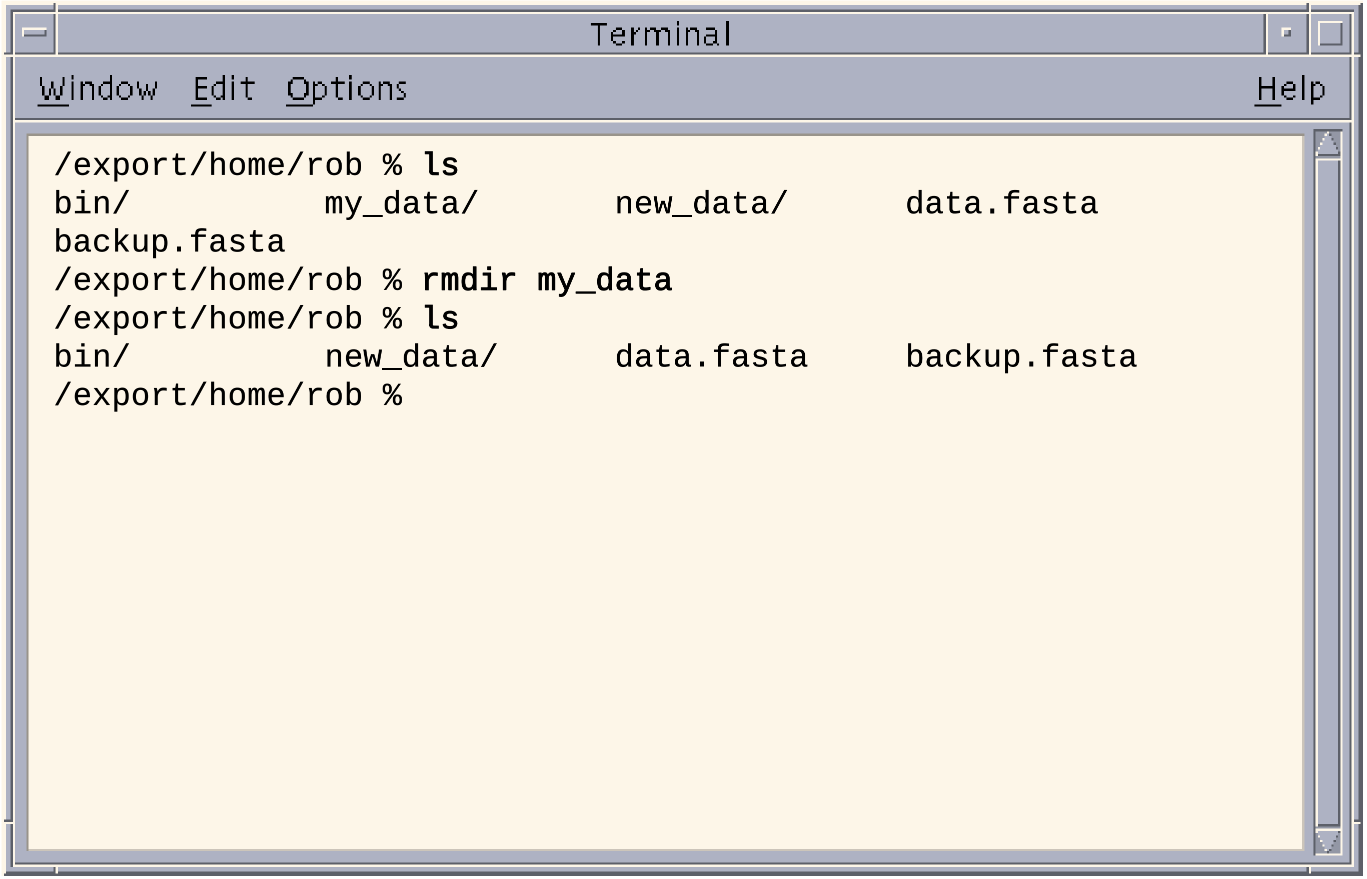
mkdir creates directories.



```
/export/home/rob % ls
bin/          my_data/          data.fasta     backup.fasta
/export/home/rob % mkdir new_data
/export/home/rob % ls
bin/          my_data/        new_data/      data.fasta
backup.fasta
/export/home/rob %
```

UNIX Commands: rmdir

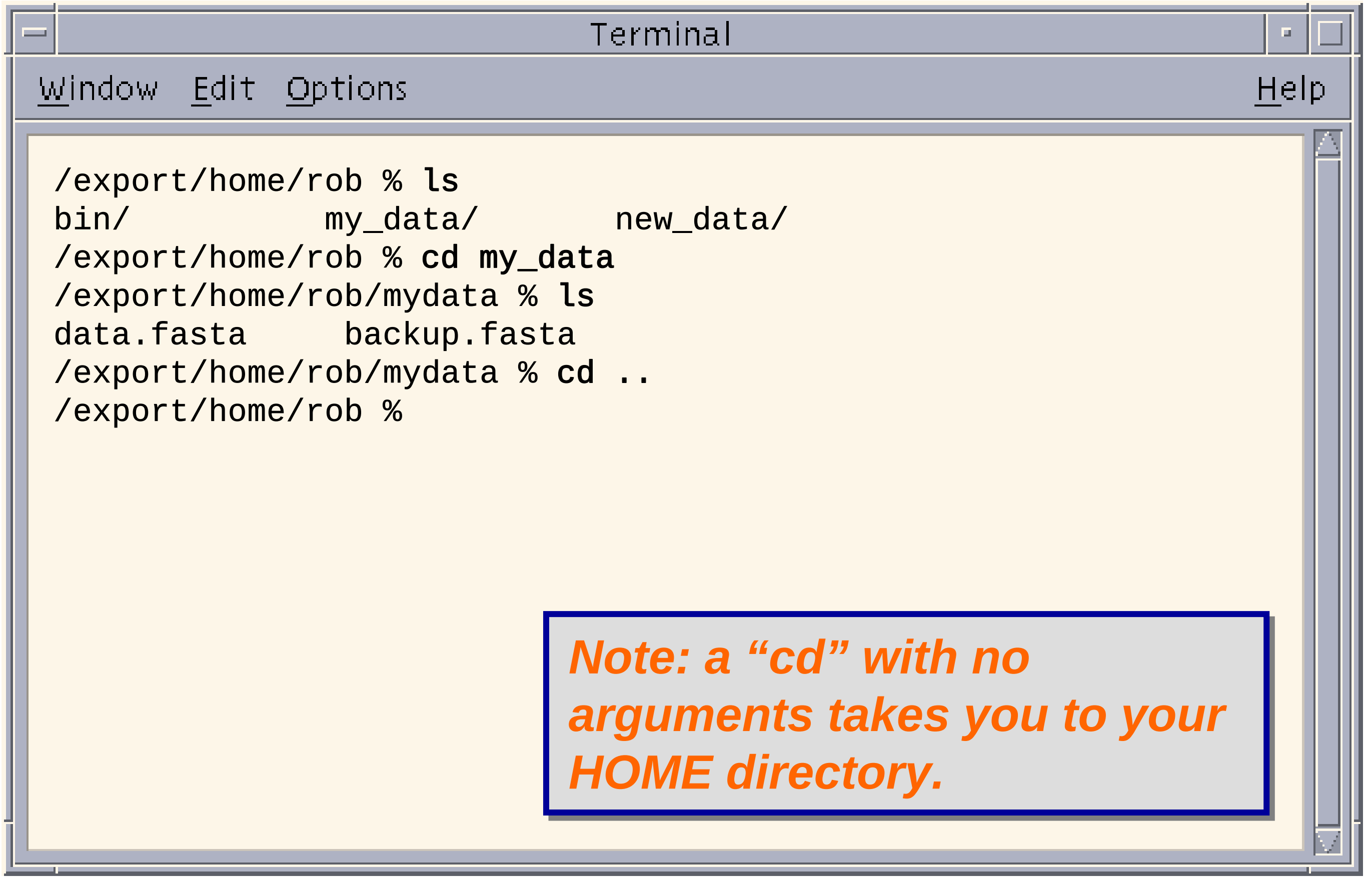
rmdir removes directories.



```
/export/home/rob % ls
bin/            my_data/        new_data/       data.fasta
backup.fasta
/export/home/rob % rmdir my_data
/export/home/rob % ls
bin/            new_data/       data.fasta      backup.fasta
/export/home/rob %
```

UNIX Commands: cd

cd changes the current directory.

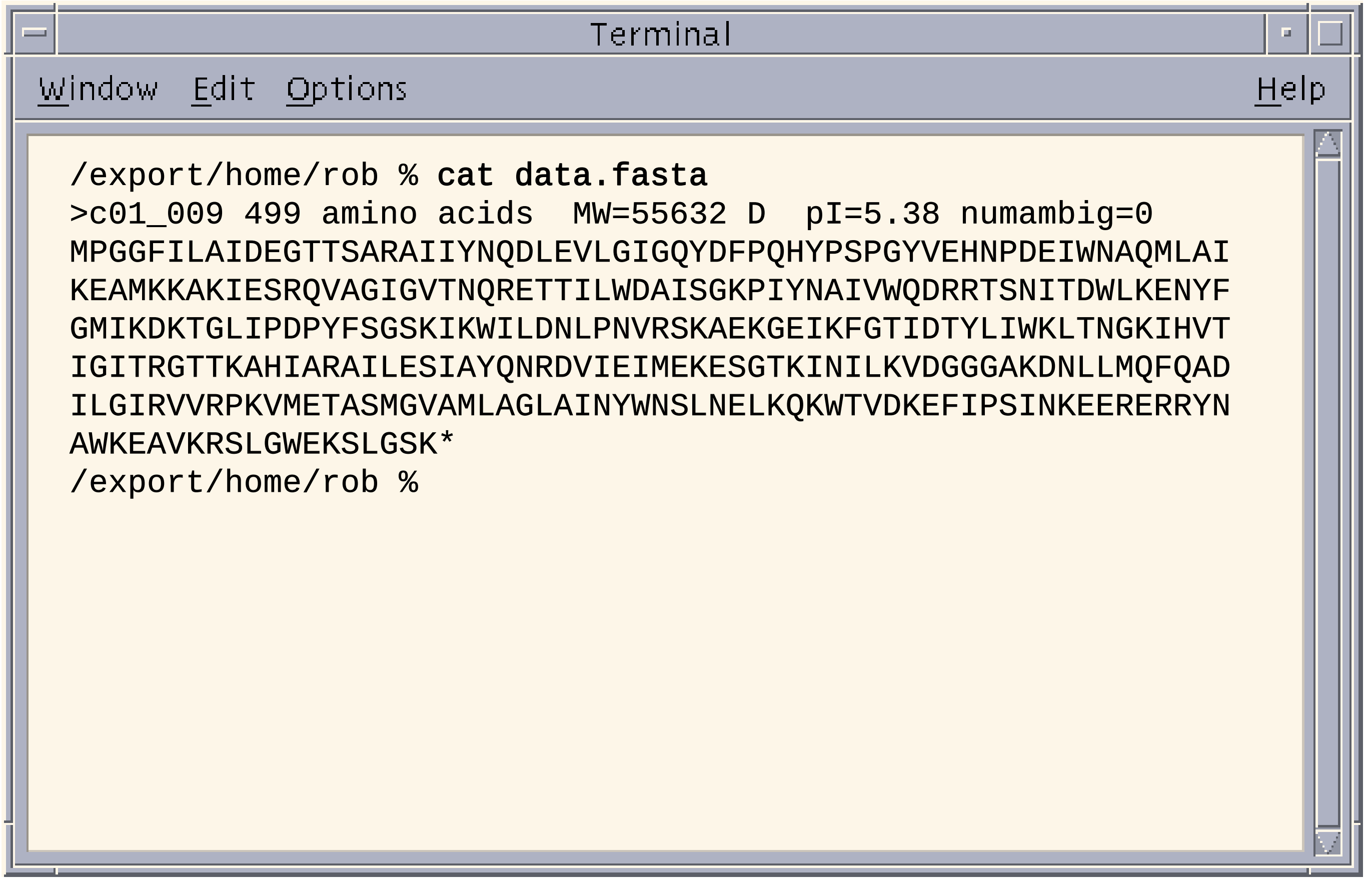


```
/export/home/rob % ls
bin/          my_data/      new_data/
/export/home/rob % cd my_data
/export/home/rob/mydata % ls
data.fasta     backup.fasta
/export/home/rob/mydata % cd ..
/export/home/rob %
```

Note: a “cd” with no arguments takes you to your HOME directory.

UNIX Commands: cat

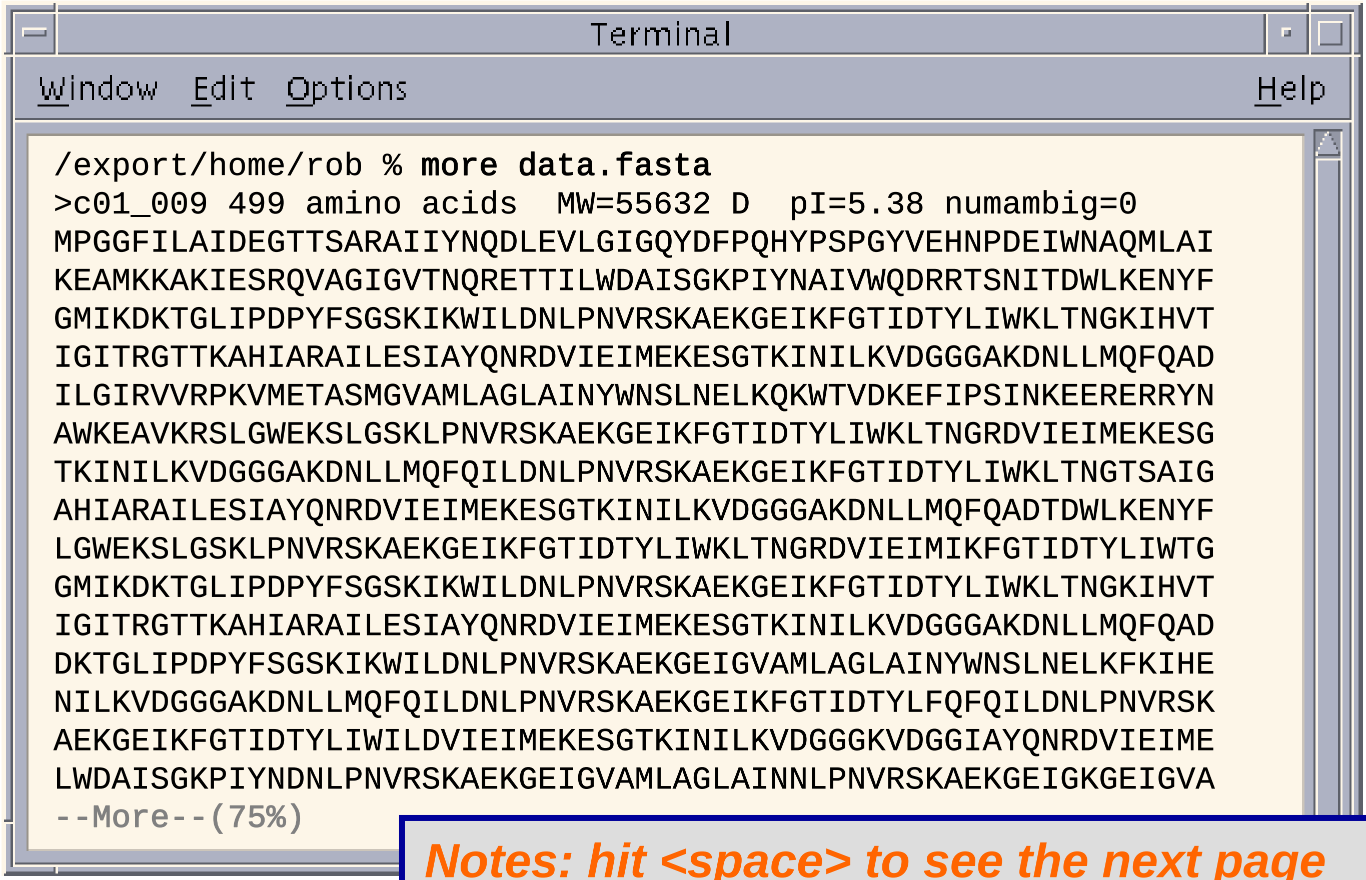
cat displays the contents of a text file:



```
/export/home/rob % cat data.fasta
>c01_009 499 amino acids  MW=55632 D  pI=5.38 numambig=0
MPGGFILAIDEGTTSARAIIYNQDLEVLGIGQYDFPQHYPSPGYVEHNPDEIWNAQMLAI
KEAMKKAKIESRQVAGIGVTNQRETTILWDAISGKPIYNAIVWQDRRTSNITDWLKENYF
GMIKDKTGLIPDPYFSGSKIKWILDNLPNVRSKAEKGEIKFGTIDTYLIWKLTNGKIHVT
IGITRGTTKAHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQAD
ILGIRVVRPKVMETASMGVAMLAGLAINYWNSLNELKQKWTVDKEFIPSINKEERERRYN
AWKEAVKRSLGWEKSLGSK*
/export/home/rob %
```

UNIX Commands: more

more displays the contents of a text file one screen's worth at a time:

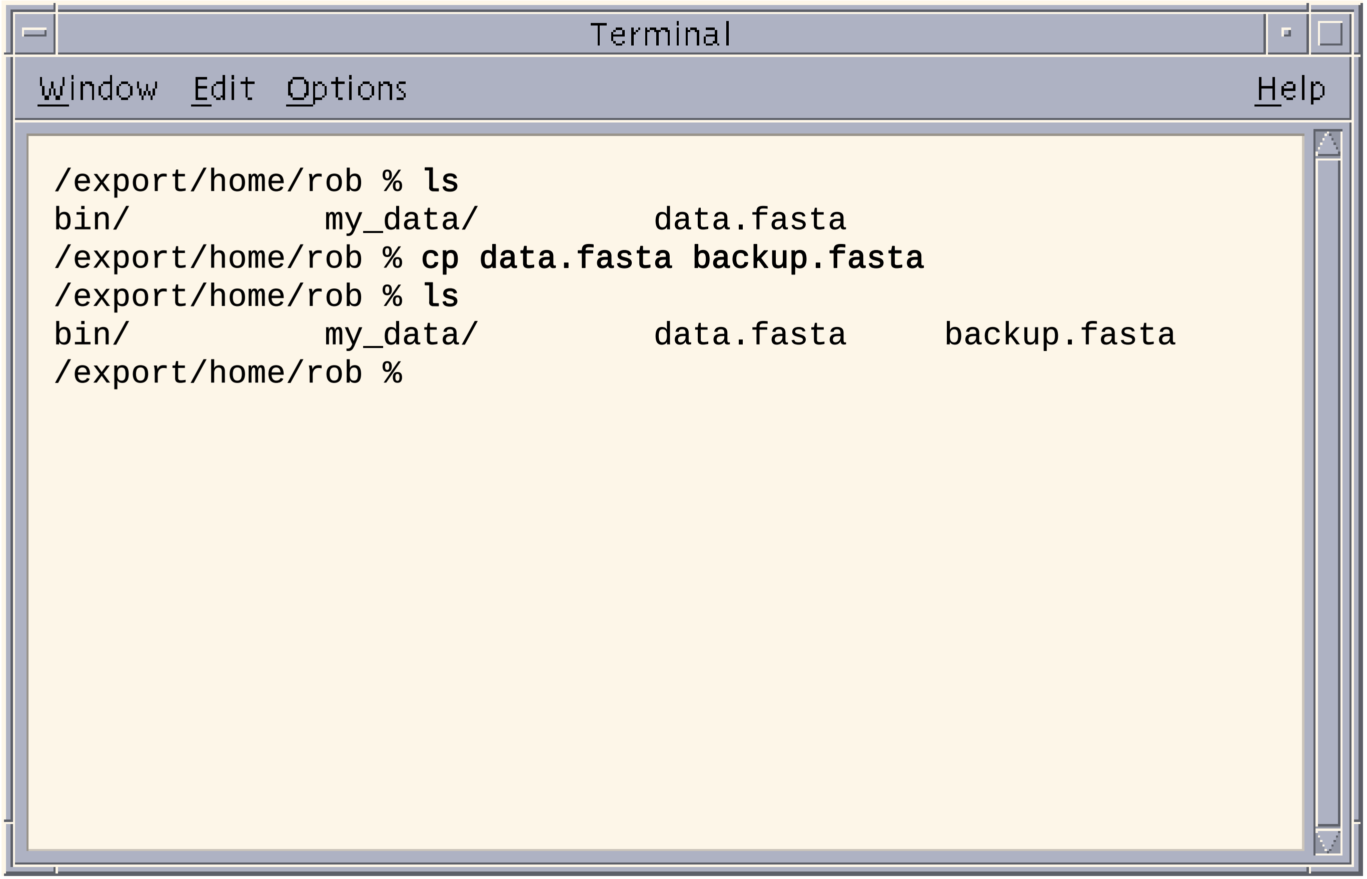


```
/export/home/rob % more data.fasta
>c01_009 499 amino acids  MW=55632 D  pI=5.38 numambig=0
MPGGFILAIDEGTTSARAIIYNQDLEVLGIGQYDFPQHYPSPGYVEHNPDEIWNAQMLAI
KEAMKKAKIESRQVAGIGVTNQRETTILWDAISGKPIYNAIVWQDRRTSNITDWLKENYF
GMIKDKTGLIPDPYFSGSKIKWILDNLPNVRSKAEKGEIKFGTIDTYLIWKLTNGKIHVT
IGITRGTTKAHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQAD
ILGIRVVRPKVMETASMGVAMLAGLAINYWNSLNELKQKWTVDKEFIPSINKEERERRYN
AWKEAVKRSLGWEKSLGSKLPNVRSKAEKGEIKFGTIDTYLIWKLTNGRDVIEIMEKESG
TKINILKVDGGGAKDNLLMQFQILDNLPNVRSKAEKGEIKFGTIDTYLIWKLTNGTSAIG
AHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQADTDWLKENYF
LGWEKSLGSKLPNVRSKAEKGEIKFGTIDTYLIWKLTNGRDVIEIMIKFGTIDTYLIWTG
GMIKDKTGLIPDPYFSGSKIKWILDNLPNVRSKAEKGEIKFGTIDTYLIWKLTNGKIHVT
IGITRGTTKAHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQAD
DKTGLIPDPYFSGSKIKWILDNLPNVRSKAEKGEIGVAMLAGLAINYWNSLNELKFKIHE
NILKVDGGGAKDNLLMQFQILDNLPNVRSKAEKGEIKFGTIDTYLFQFQILDNLPNVRSK
AEKGEIKFGTIDTYLIWILDVIEIMEKESGTKINILKVDGGGKVDGGIAYQNRDVIEIME
LWDAISGKPIYNDNLPNVRSKAEKGEIGVAMLAGLAINNLPNVRSKAEKGEIGKGEIGVA
--More--(75%)
```

Notes: hit <space> to see the next page
hit "q" to quit, "/" to search, read the man page.
"less" is an enhanced version of "more" on Linux

UNIX Commands: cp

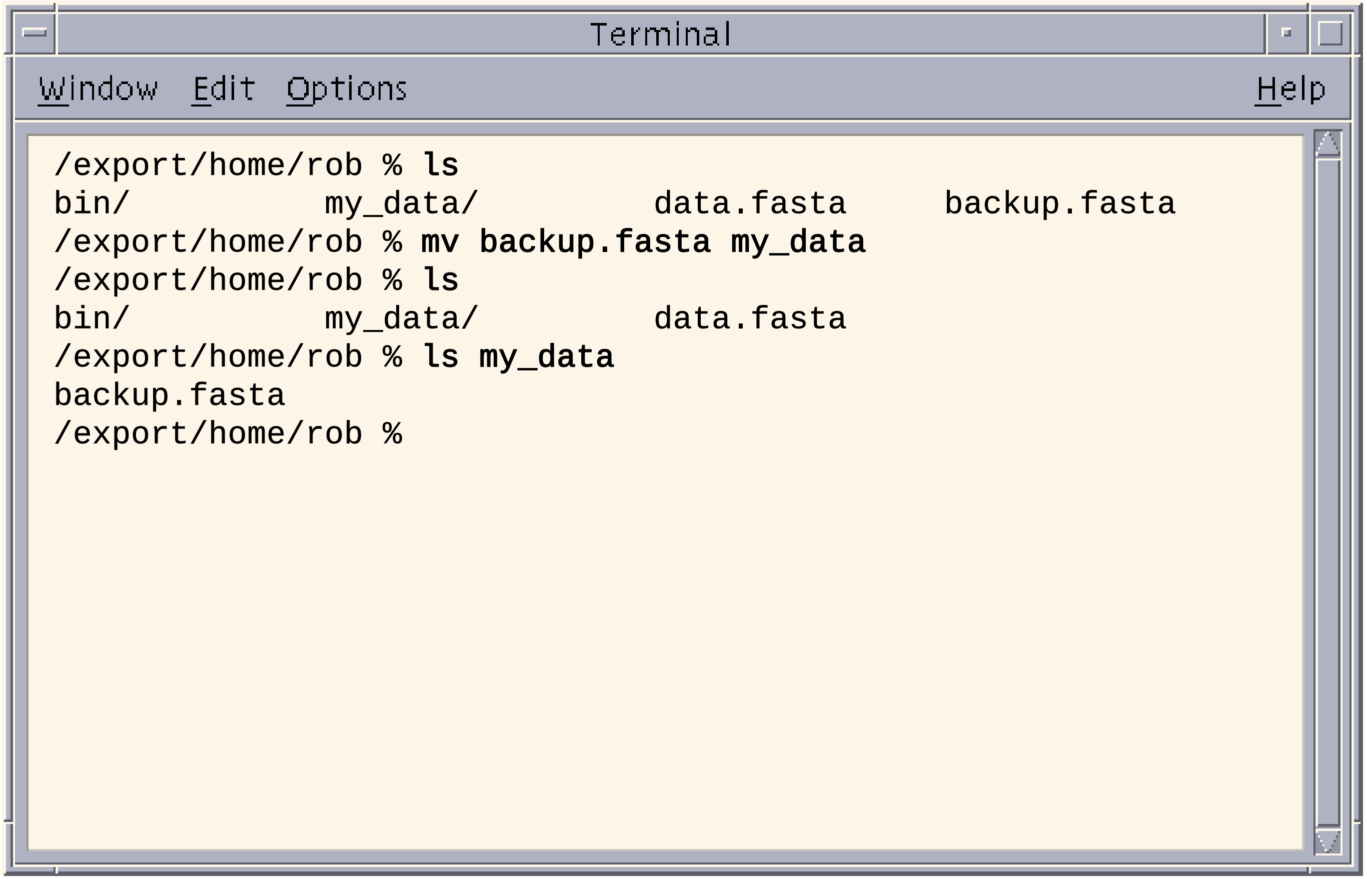
cp copies files



```
/export/home/rob % ls
bin/          my_data/        data.fasta
/export/home/rob % cp data.fasta backup.fasta
/export/home/rob % ls
bin/          my_data/        data.fasta     backup.fasta
/export/home/rob %
```

UNIX Commands: mv

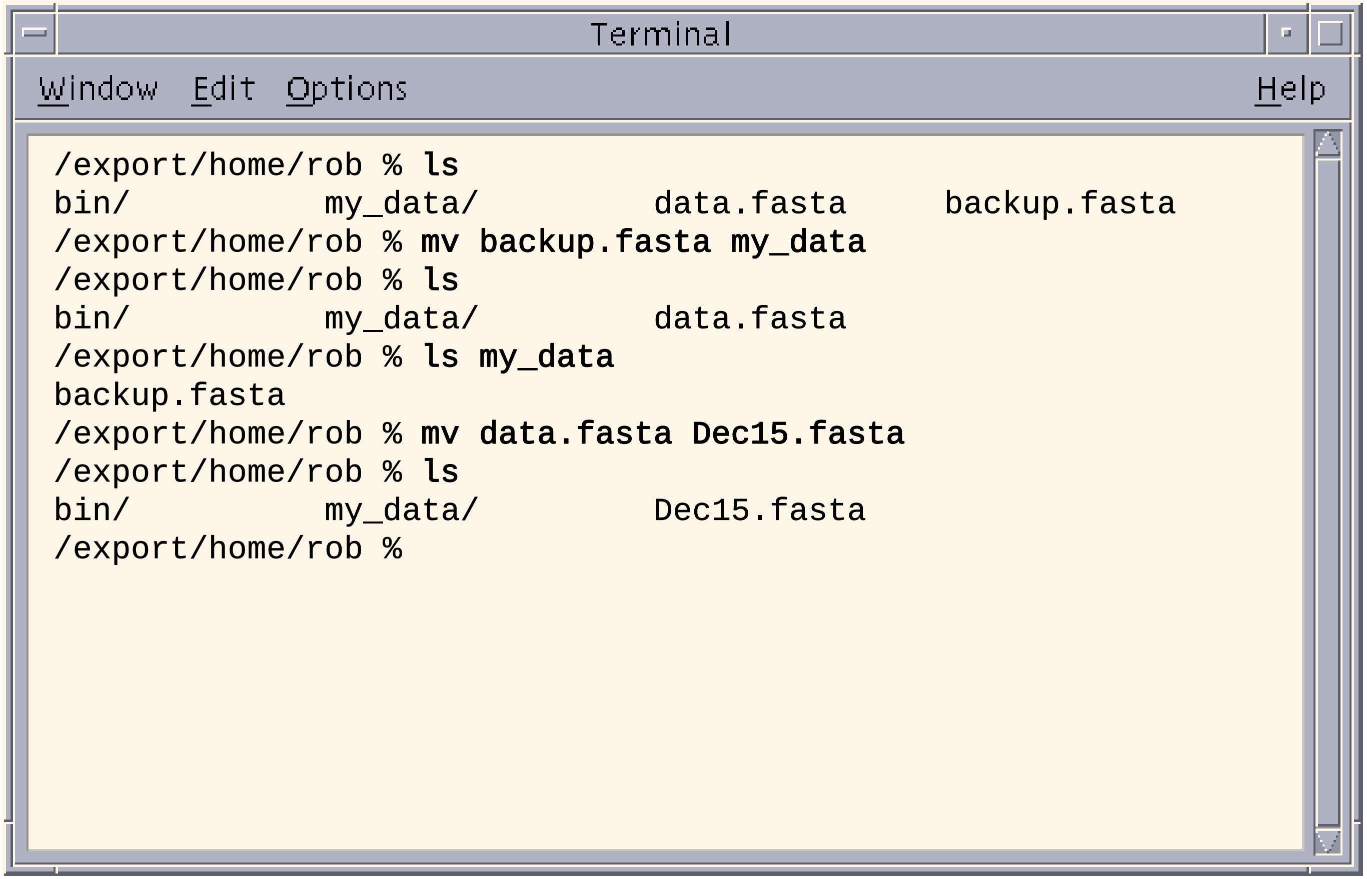
mv moves files



```
/export/home/rob % ls
bin/          my_data/         data.fasta     backup.fasta
/export/home/rob % mv backup.fasta my_data
/export/home/rob % ls
bin/          my_data/         data.fasta
/export/home/rob % ls my_data
backup.fasta
/export/home/rob %
```

UNIX Commands: mv

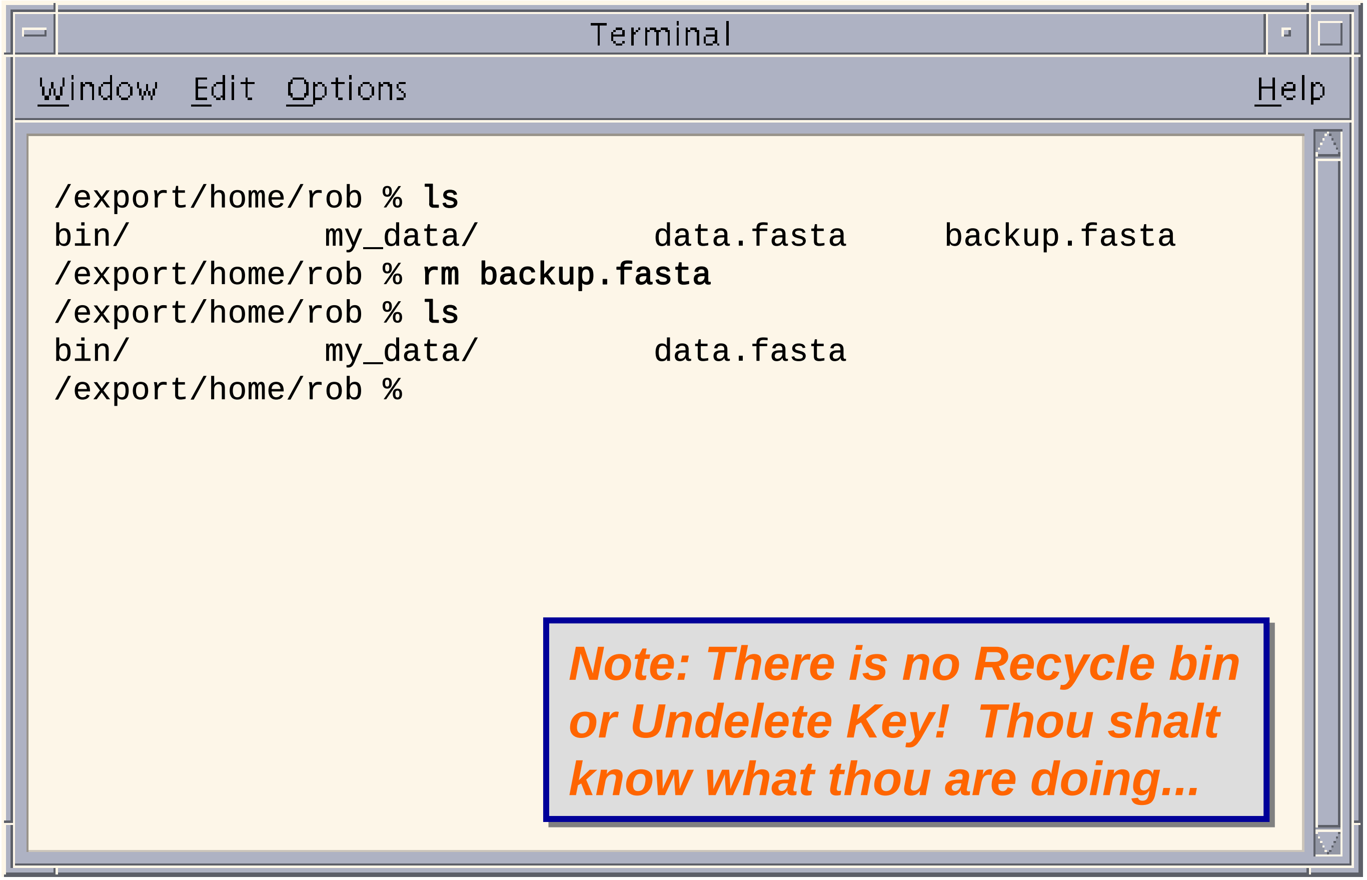
mv also renames files



```
/export/home/rob % ls
bin/          my_data/          data.fasta     backup.fasta
/export/home/rob % mv backup.fasta my_data
/export/home/rob % ls
bin/          my_data/          data.fasta
/export/home/rob % ls my_data
backup.fasta
/export/home/rob % mv data.fasta Dec15.fasta
/export/home/rob % ls
bin/          my_data/          Dec15.fasta
/export/home/rob %
```

UNIX Commands: rm

rm deletes files - *permanantly.*



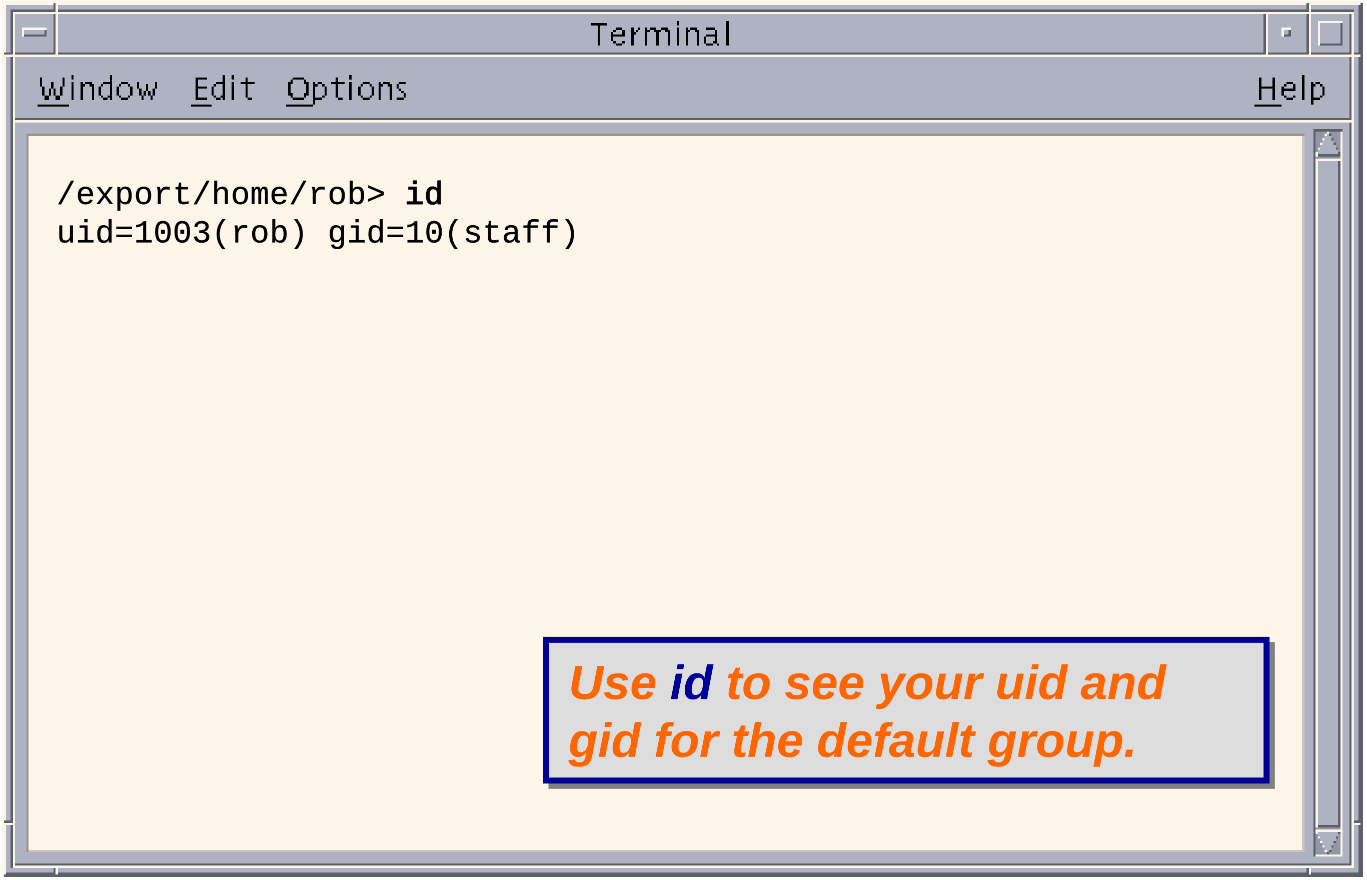
```
/export/home/rob % ls
bin/          my_data/         data.fasta     backup.fasta
/export/home/rob % rm backup.fasta
/export/home/rob % ls
bin/          my_data/         data.fasta
/export/home/rob %
```

Note: There is no Recycle bin or Undelete Key! Thou shalt know what thou are doing...

UNIX Commands: head & tail

- head displays the *top* of a file
  - **`head -n`** displays the top **n** lines
  - default is 10
- tail displays the *bottom* of a file
  - **`tail -n`** displays the bottom **n** lines
  - default is 10
  - **`tail +n`** displays the file starting at line **n**

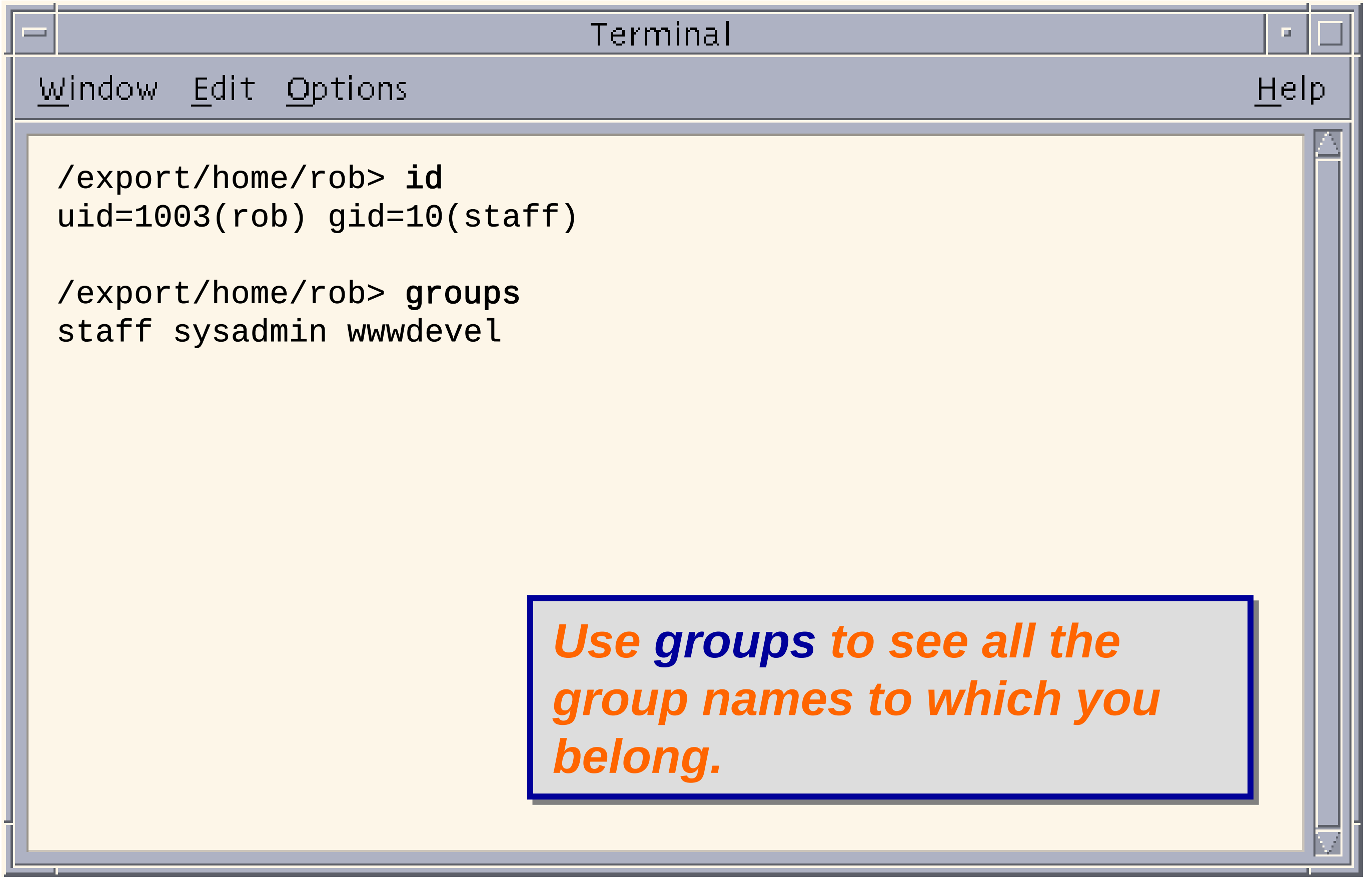
UNIX Commands: id



```
/export/home/rob> id
uid=1003(rob) gid=10(staff)
```

Use id to see your uid and gid for the default group.

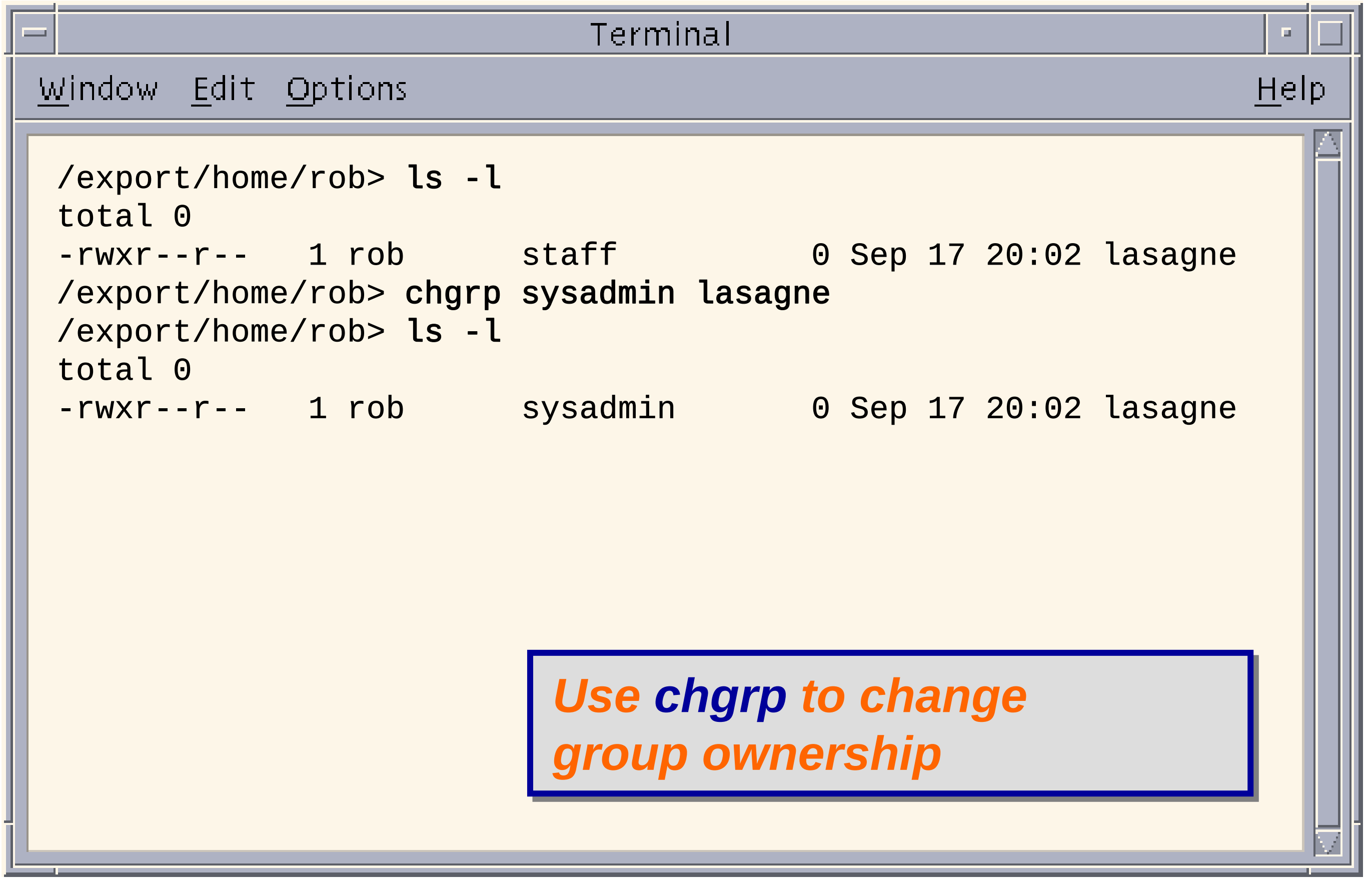
UNIX Commands: groups



```
/export/home/rob> id
uid=1003(rob) gid=10(staff)

/export/home/rob> groups
staff sysadmin wwwdevel
```

*Use **groups** to see all the group names to which you belong.*

UNIX Commands: chgrp



```
/export/home/rob> ls -l
total 0
-rwxr--r--   1 rob      staff          0 Sep 17 20:02 lasagne
/export/home/rob> chgrp sysadmin lasagne
/export/home/rob> ls -l
total 0
-rwxr--r--   1 rob      sysadmin       0 Sep 17 20:02 lasagne
```

Use chgrp to change group ownership

UNIX Commands: find

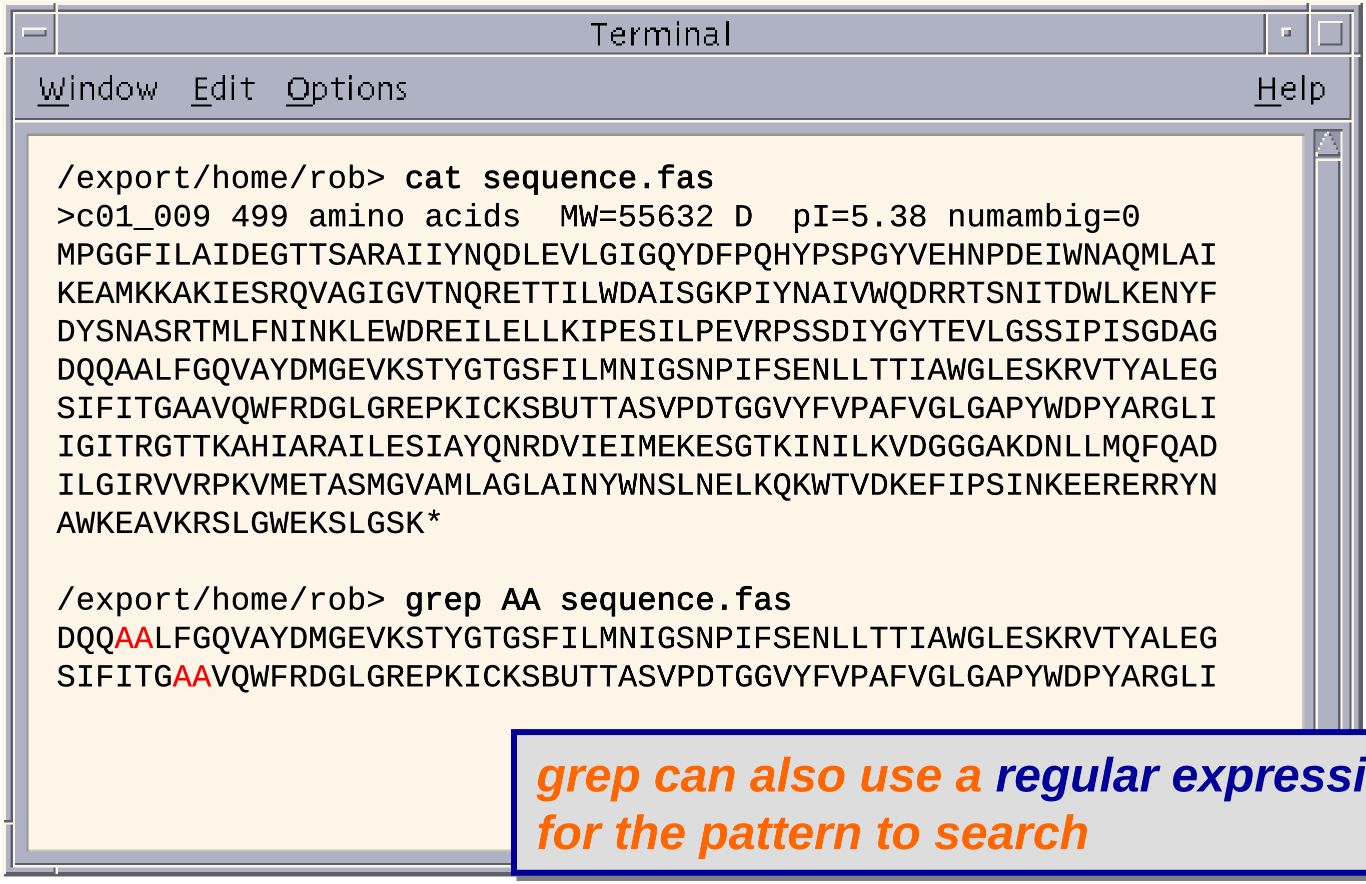
- At its simplest, find searches the filesystem for files whose name matches a specific pattern
- However, it can do a lot more and is one of the most useful commands in Unix (as it can find specific files and then perform operations on them)

- Here is a simple example:

```
> ls
dir1  foo  foo2

> find . -name foo -print
./foo
```

UNIX Commands: grep

grep extracts lines from a file that match a given string or pattern



```
/export/home/rob> cat sequence.fas
>c01_009 499 amino acids  MW=55632 D  pI=5.38 numambig=0
MPGGFILAIDEGTTSARAIIYNQDLEVLGIGQYDFPQHYPSPGYVEHNPDEIWNAQMLAI
KEAMKKAKIESRQVAGIGVTNQRETTILWDAISGKPIYNAIVWQDRRTSNITDWLKENYF
DYSNASRTMLFNINKLEWDREILELLKIPESILPEVRPSSDIYGYTEVLGSSIPISGDAG
DQQAALFGQVAYDMGEVKSTYGTGSFILMNIGSNPIFSENLLTTIAWGLESKRVTYALEG
SIFITGAAVQWFRDGLGREPKICKSBUTTASVPDTGGVYFVPAFVGLGAPYWDPYARGLI
IGITRGTTKAHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQAD
ILGIRVVRPKVMETASMGVAMLAGLAINYWNSLNELKQKWTVDKEFIPSINKEERERRYN
AWKEAVKRSLGWEKSLGSK*

/export/home/rob> grep AA sequence.fas
DQQAALFGQVAYDMGEVKSTYGTGSFILMNIGSNPIFSENLLTTIAWGLESKRVTYALEG
SIFITGAAVQWFRDGLGREPKICKSBUTTASVPDTGGVYFVPAFVGLGAPYWDPYARGLI
```

grep can also use a regular expression for the pattern to search

Regular Expressions

- In addition to grep, a number of Unix commands support the use of *regular expressions* to describe patterns:
  - sed
  - awk
  - perl
- General search pattern characters:
  - Any character (*except a metacharacter*) matches itself
  - "." matches any character except a newline
  - "*" matches zero or more occurrences of the single preceding character
  - "+" matches one or more of the proceeding character
  - "?" matches zero or one of the proceeding character
- Additional special characters:
  - "()" parentheses are used to quantify a sequence of characters
  - "|" works as an OR operator
  - "{}" braces are used to indicate ranges in the number of occurrences

Regular Expressions

- If you really want to match a period '**.**', you need to escape it with a backslash "\."

Regexp	**Matches**	**Does not match**
a.b	axb	abc
a\.b	a.b	axb

Regular Expressions

- A *character class*, also called a character set can be used to match only one out of several characters
- To use, simply place the characters you want to match between square brackets []
- You can use a hyphen inside a character class to specify a range of characters
- Placing a caret (^) after the opening square bracket will negate the character class. The result is that the character class will match any character that is *not* in the character class
- Examples:

[abc]	matches a *single* a b or c
[0-9]	matches a *single* digit between 0 and 9
[^A-Za-z]	matches a single character as long as it is not a letter

Regular Expressions

- Since certain character classes are used often, a series of shorthand character classes are available for convenience:

  \d a digit. eg [0-9]
  \D a non-digit, eg. [^0-9]
  \w a word character (matches letters and digits)
  \W a non-word character
  \s a whitespace character
  \S a non-whitespace character

Regular Expressions

- More shorthand classes are available for *matching boundaries*:

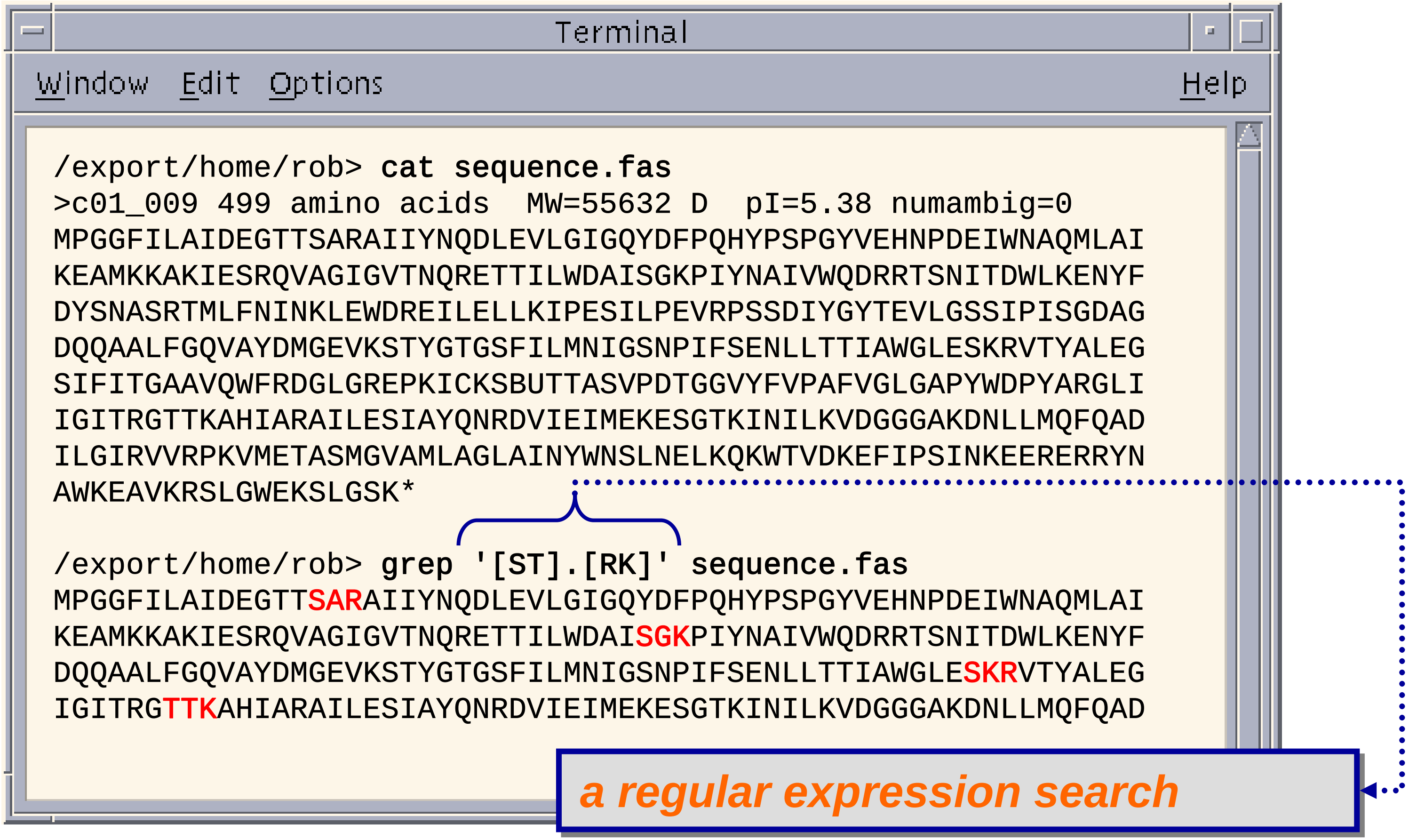
^	the beginning of a line
$	the end of a line
\b	a word boundary
\B	a non-word boundary
\A	the beginning of the input
\z	the end of the input

Regular Expressions Examples

- “notice” a string that has the text "notice" in it
- “F.” matches an “F” followed by any character
- “a.b” matches “a” followed by any 1 char followed by “b”
- “^The” matches any string that starts with "The"
- “oh boy$” matches a string that ends in the substring "oh boy";
- “^abc$” matches a string that starts and ends with "abc" -- that could only be "abc" itself!
- “ab*” matches an “*a*” followed by zero or more “*b*”"s ("a", "ab", "abbb", etc.)
- “ab+” similar to previous, but there's at least one “*b*” ("ab", "abbb", etc.)
- “(b|cd)ef” matches a string that has either "bef" or "cdef"
- “a(bc)*” matches an “*a*” followed by zero or more copies of the sequence "bc"
- “ab{3,5}” matches an “*a*” followed by three to five “*b*”"s ("abbb", "abbbb", or "abbbbb")
- “[Dd][Aa][Vv][Ee]” matches "Dave" or "dave" or "dAVE“, does not match "ave" or "da"

UNIX Commands: grep

grep extracts lines from a file that match a given string or pattern



```
/export/home/rob> cat sequence.fas
>c01_009 499 amino acids  MW=55632 D  pI=5.38 numambig=0
MPGGFILAIDEGTTSARAIIYNQDLEVLGIGQYDFPQHYPSPGYVEHNPDEIWNAQMLAI
KEAMKKAKIESRQVAGIGVTNQRETTILWDAISGKPIYNAIVWQDRRTSNITDWLKENYF
DYSNASRTMLFNINKLEWDREILELLKIPESILPEVRPSSDIYGYTEVLGSSIPISGDAG
DQQAALFGQVAYDMGEVKSTYGTGSFILMNIGSNPIFSENLLTTIAWGLESKRVTYALEG
SIFITGAAVQWFRDGLGREPKICKSBUTTASVPDTGGVYFVPAFVGLGAPYWDPYARGLI
IGITRGTTKAHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQAD
ILGIRVVRPKVMETASMGVAMLAGLAINYWNSLNELKQKWTVDKEFIPSINKEERERRYN
AWKEAVKRSLGWEKSLGSK*

/export/home/rob> grep '[ST].[RK]' sequence.fas
MPGGFILAIDEGTTSARAIIYNQDLEVLGIGQYDFPQHYPSPGYVEHNPDEIWNAQMLAI
KEAMKKAKIESRQVAGIGVTNQRETTILWDAISGKPIYNAIVWQDRRTSNITDWLKENYF
DQQAALFGQVAYDMGEVKSTYGTGSFILMNIGSNPIFSENLLTTIAWGLESKRVTYALEG
IGITRGTTKAHIARAILESIAYQNRDVIEIMEKESGTKINILKVDGGGAKDNLLMQFQAD
```

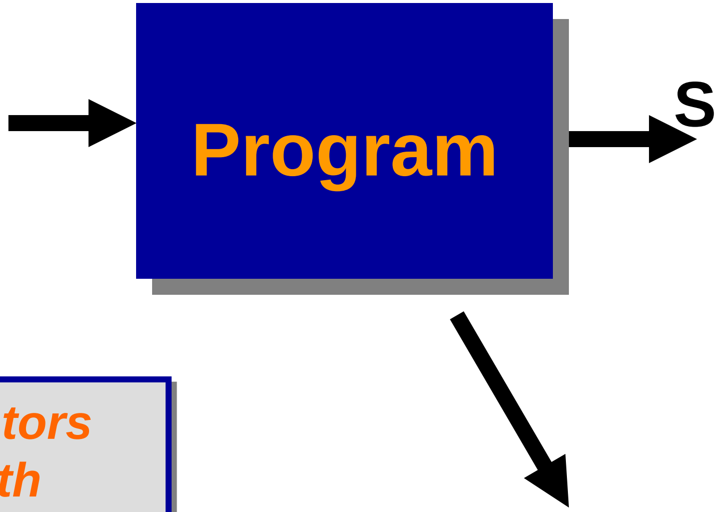
a regular expression search

Interacting with the Shell

Running a Unix Program

- Typically, you type in the name of a program and some command line options
- The shell reads this line, finds the program and runs it, feeding it the options you specified
- The shell establishes 3 separate I/O *streams*:
  - Standard Input
  - Standard Output
  - Standard Error

Programs and Standard I/O



Standard Input (STDIN)

Program

Standard Output (STDOUT)

Standard Error (STDERR)

Note: File descriptors are associated with each stream

- *0=STDIN*
- *1=STDOUT*
- *2=STDERR*

Defaults for I/O

- When a shell runs a program for you:
  - standard input is your keyboard
  - standard output is your screen or window
  - standard error is your screen or window
- If standard input is your keyboard, you can type stuff in that goes to a program
- To end the input you press Ctrl-D (^D) on a line by itself, this ends the input *stream*
- The shell is a program that reads from standard input
- Any idea what happens when you give the shell ^D?

UNIX: Shell Flavors

- There are two main ‘flavors’ of shells:
  - Bourne created what is now known as the standard shell: “sh”, or “bourne shell”. It’s syntax roughly resembles Pascal. It’s derivatives include “ksh” (“korn shell”) and now, the most widely used, “bash” (“bourne again shell”)
  - One of the creators of the C language implemented a shell to have a “C-programming” like syntax. This is called “csh” or “C-shell”. Today’s most widely used form is the very popular “tcsh”
- Shells can run interactively or as a *shell script*

Customization

- Each shell supports some customization.
  - user prompt settings
  - environment variable settings
  - aliases
- The customization takes place in *startup* files which are read by the shell when it starts up
  - Global files are read first - these are provided by the system administrators (eg. /etc/profile)
  - Local files are then read in the user's HOME directory to allow for additional customization

Shell Startup Files

```
sh,ksh:
   ~/.profile
bash:
   ~/.bash_profile
   ~/.bash_login
   ~/.profile
   ~/.bashrc
   ~/.bash_logout
csh:
   ~/.cshrc
   ~/.login
   ~/.logout
tcsh:
   ~/.tshrc
   ~/.cshrc
   ~/.login
   ~/.logout
```

Note: on TACC production systems, we provide an alternative location for customization files to avoid over-riding system defaults:

BASH:	*~/.profile_user*
CSH/TCSH:	*~/.login_user* *~/.cshrc_user*

Wildcards for Filename Abbreviation

- When you type in a command line the shell treats some characters as special (*metacharacters)*

- These special characters make it easy to specify filenames

- The shell processes what you give it, using the special characters to replace your command line with one that includes a bunch of file names

The special character *

- “*” matches anything.
- If you give the shell “*” by itself (as a command line argument), the shell will remove the * and replace it with all the filenames in the current directory.
- ***“a*b”*** matches all files in the current directory that start with **a** and end with **b**.

Understanding *

- The **echo** command prints out whatever you tell it:

```
> echo hi
hi

> ls
dir1  foo  foo2
```

- What will the following command do?

```
> echo *
dir1 foo foo2
```

Shell Stream Redirection

- A very powerful function in Unix is redirection for input and output:
  - The shell can attach things other than your *keyboard* to *standard input (stdin)*
    - A file (the contents of the file are fed to a program as if you typed it) - common in scientific programming
    - A pipe (the output of another program is fed as input as if you typed it)
  - The shell can attach things other than your *screen* to *standard output (stderr)*
    - A file (the output of a program is stored in file)
    - A pipe (the output of a program is fed as input to another program

Stream Redirection

- To tell the shell to store the *output* of your program in a file, follow the command line for the program with the “>” character followed by the filename:

```
ls > lsout
```

- The command above will create a file named **`lsout`** and place the output of the **`ls`** command in the file

Stream Redirection

- To have the shell get standard *input* from a file, use the “<“ character:

```
sort < nums
```

- The command above would sort the lines in the file **nums** and send the result to *stdout*

- Beauty of redirection is that you can do both forms together:

```
sort < nums > sortednums
```

Modes of Output Redirection

- There are two modes of output redirections:
  - “>” the create mode
  - “>>” the append mode

- For example:
  - the command **`ls > foo`** will create a new file named foo (deleting any existing file named foo).
  - if you use “**>>**” instead, the output will be appended to foo:

```
ls /etc >> foo
ls /usr >> foo
```

Stream Redirection

- Many commands send error messages to *standard error (stderr)* which is different from *stdout*.

- However, the “>” output redirection only applies to *stdout* (not *stderr*)

- To redirect *stderr* to a file you need to know what shell you are using:
  - BASH
    - **“2>”** redirects *stderr* (eg. **`ls foo blah gork 2> erroroutput )`**
    - **“&>”** redirects *stdout* and *stderr* (eg. **`ls foo &> /dev/null )`**
  - TCSH
    - **“>&”** merges ***stdout*** and ***stderr*** and sends to a file:
      `ls foo blah >& saveboth`
    - **“>>&”** *merges* ***stdout*** and ***stderr*** and appends to a file:
      `ls foo blah >>& saveboth`

References/Acknowledgements

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- Regular expression info (http://www.regular-expressions.info/reference.html)