ECOL 553L

System, ``, index, advanced sorting

The Perl `system()` function

- Perl's `system` function runs an external command from inside a script. The `system` function returns an error code value, with zero normally meaning that the command executed without error. Run '`perldoc -f system`' for more info.

- Example:

```
# Run blastn command for 2 sequences
#(no blast database!)
$command = "blastn -query seqA.fa -subject seqB.fa -out  AB.bln";
$return_code = system($command);
if ($return_code) {
   print "blastn returned $return_code \n";
}
```

More about `if/while` conditions

- In the last `blastn` example, the return code was checked as follows:

```
#  Run blastn command
$cmd = "blastn -query seqA.fa –subject seqB.fa –out AB.bln";
$return_code = system($cmd);
if ($return_code) {
   print "blastn returned $return_code \n";
}
```

- Conditions in if/while tests evaluate to 0 or 1
  - (0 = False, 1 = True)

- `if($return_code)` is the same as `if($return_code != 0)`
  - But NOT the same as `if (!defined $return_code)`
  - `$return_code` was defined by the assignment:
    - `$return_code = system($command);`

More about `defined` vs `!defined`

- Under what circumstances are variables not defined?

- `@ARGV` is undefined if no command line arguments are specified when the script is run
- `$ARGV[1]` is undefined if only ONE command line argument is provided
  - Why?

- `$count` is undefined after a "`my`" statement with no initialization:
  - `my $count;`
- `$count` IS defined after it gets set to any value, including zero:
    - `$count = 0;`
  - Or
    - `$count = 1;`
  - Or
    - `$count++;`

Perl backtics ` `

- If you need your Perl script to capture the output of an external program, use backtics `` instead of the system function. The backtics surround a command string, and the output of the command is returned as an array of lines.
  - **Backtics are distinct from single quotes!**
- Examples:

```
# Run blastn and capture results in array
@result = `blastn -query seqA.fa -subject seqB.fa`;
$hit_count = 0;
foreach $lin (@result) {
   $hit_count++;
   print "$hit_count\t$lin";
}

# Run EMBOSS  msbar program to mutate $seqfile sequences
@result = `msbar $seqfile -count 10 -point 4 -stdout -auto`;
print OUTFILE "@result\n";
```

More backtics examples

```
# Run "wc -l" on a group of files, one at a time
$snpdata = $ARGV[0];
@files = glob("$snpdata/*SNP*.csv");
foreach $fil  (@files) {
   print "$file has ", `wc -l $fil`, " lines\n";
}
```

- If the `glob()` line is replaced with the following, will the `@lsfiles` array contain exactly the same items as `@files`?

```
@lsfiles = `ls $snpdata/*SNP*.csv`;
```

- What line of code could be added to make `@lsfiles` identical to `@files`?

The `substr` function

- Recall that the function `substr` can be used to extract a substring from a given string.

- `substr` takes a string argument, starting position, and desired number of characters and returns a string
  - Example:
  - `$dna = "ATGCGTCATCGTAGTCA";`
  - `$first4 = substr($dna, 0, 4);`
  - `print "First 4 bases are $first4 \n";`

- What would the following code do?
  - `$dna = "ATGCGTCATCGTAGTCA";`
  - `$dna_substr = substr($dna, 2, 6);`

More about the `substr` function

- The `substr` function is very flexible. You can get substrings from a given position to the end of the string, get substrings at the end of a string, and even replace substrings when given a 4th argument.

  - Examples:
    - `$dna = "ATGCGTCATCGTAGTCAAAAAAA";`
    - `$dna_3 _to_end = substr($dna, 3);`
    - `$dna_last5 = substr($dna, -5);`
    - `$change_startc = substr($dna, 0, 3, "AUG");`

The index function

- The index function is used to determine the position of a letter or a substring in a string. Arguments are string, substring, starting position. Value returned is position where substring is found, or `-1` if substring is not found.
- Examples:

```
$dna = "CGCAGCAGTAGCTACAGCAGCAGAAA";
$motif = "CAG";
$pos = index($dna, $motif, 0);
print "First occurrence of $motif found at position $pos\n";

# scan entire string
$pos = 0;
while (($pos = index($seq, $motif, $pos)) >= 0) {
   print "Found $motif at $pos\n";
   $pos++;  #what happens without this?
}
```

The `split` function

- The function `split` can help parse Tab-delimited, comma-separated, or any data with a separator that can be represented by a pattern.
- `split` takes a split pattern and a string argument and returns an array of pieces of the string.
    - The pattern is delimited by a pair of forward slashes `//` .
    - The parts of the string that matched the pattern are not returned.
    - The original string is not modified.

- Example:

```
$seqID = "gi|259144736|emb|FN393060.1|";
# To split apart on | need to escape with \
@parts = split(/\|/, $seqID);
print "Accession number is $parts[3] \n";
```

- How many elements are in the `@parts` array?

The join() function

- Recall that the `split` function takes a string, splits it on a pattern, and returns an array. The `join` function takes an array, joins it together with a connector string and returns a new string:
  - For the code:

```
@items = ("A","B","C","D");
$new_str = join("+", @items);
print "Joined string is: $new_str \n";
```

  - The output is:

```
Joined string is: A+B+C+D
```

More about the `join` function

- The perl `join()` function is complementary to split().
- Example: To build a comma separated string from an array:

```
$cstring = join (",",  @array);
```

- Note that `join` does not use patterns like `split` does!
- However, you can use more that one character to join elements:

```
$word_list = join (" and ", @words);
$link_str =  join ('…', @links);
```

The Perl `grep` function

- The `grep` function in Perl is similar to Unix grep,
  - except that it searches an array and returns a sub-array containing references to elements that matched the specified pattern.
  - Note that the pattern match does not have to occur at the beginning of an element. (We will learn how to do that later.)

```
# How many names will be in @capB?  In @smallB?
@names = ("Bill K", "Barb C", "Jen A", "Jen B", "Robyn Z");
@capB = grep (/B/, @names);
@smallB grep (/b/, @names);

# Check for Minus/Plus in BLAST output Strand= lines
@strand = `grep Strand $file.bln`;
@minus = grep (/Minus/, @strand);
@plus = grep (!/Minus/, @strand);
# Would it work to use @plus = grep (/Plus/, @strand)?
```

More about the `grep` function

- The perl `grep()` function searches array elements for matches to a pattern.
  - We will learn more about patterns soon, but for now we'll use simple strings as patterns.
- Examples:
  - To search for array elements containing an upper case A:

```
@bigA = grep (/A/,  @array);
```

  - To search for array elements containing upper/lower case A:

```
@anyA = grep (/A/i,  @array);
```

  - Do you notice any similarities with Unix grep?
  - You can use variables inside a pattern:

```
@found = grep (/$search/,  @array);
```

Even more about the grep function

- You can also use grep in scalar context to test whether there are any matches. In this case grep returns True or False:

```
if (grep (/$search/,  @array)) {
      print "Found  $search in array\n";
} else {
      print "$search not found in array\n";
}
```

- The `grep()` function can be used with a conditional (`if`) expression instead of a pattern.

- Example:
  - To find all filenames in an array that are directories:

```
@dirs = grep (-d,  @files);
```

Numeric sorting

- Earlier we learned about the sort function:

```
@items = ("Greg Bear",  42,  "X",  3.5e-107);
@sorted = sort (@items);
print "The sorted items are @sorted \n";
```

- By default, sort does an alphabetical sort. If we want to sort numerically we have to use the numeric comparison operator <=> :

```
@nums = (  42,  17,  3.5e-107, 4e20, 6.6);
@sorted = sort {$a  <=> $b} @nums;     # sort ascending
print "The numbers low to high are @sorted \n";
```

- For descending numeric sort, exchange `$a` and `$b`:

```
@nums = (  42,  17,  3.5e-107, 4e20, 6.6);
@sorted = sort {$b <=> $a} @nums;
print "The numbers high to low are @sorted \n";
```

More about sorting in Perl

- Perl provides a great deal of flexibility in sorting. The sort function can use a code block or a subroutine as instructions on how to sort items in a list. We've seem code block examples:

```
@sorted = sort {$a  <=> $b} @nums; #sort ascending
print "The numbers low to high are @sorted \n";
```

- To sort BLAST results primarily by length of match, then secondarily by e-values, then thirdly by percent identity, we can write a subroutine for sort:

```
@sorted = sort bsort @lines;
print "The sorted BLAST results are @sorted \n";
```

- How do we think we would use this to “sort” a hash by the values?

```
my %hash
my @sortedKeys =                                    #sort ascending
              sort {$hash{$a} <=> $hash{$b}} keys %hash;
foreach my $k (@sortedKeys){ print “$hash{$k} “; }
```

Writing more powerful scripts

- Up to this point we have learned about individual concepts in Perl. We now have enough knowledge to begin putting more complex scripts together, from start to finish.

- We've talked about incremental development and testing, but there are other techniques worth exploring. Two of these are Concept Maps and Pseudocode.

- Concept Maps can help organize data flow and concepts/ relationships

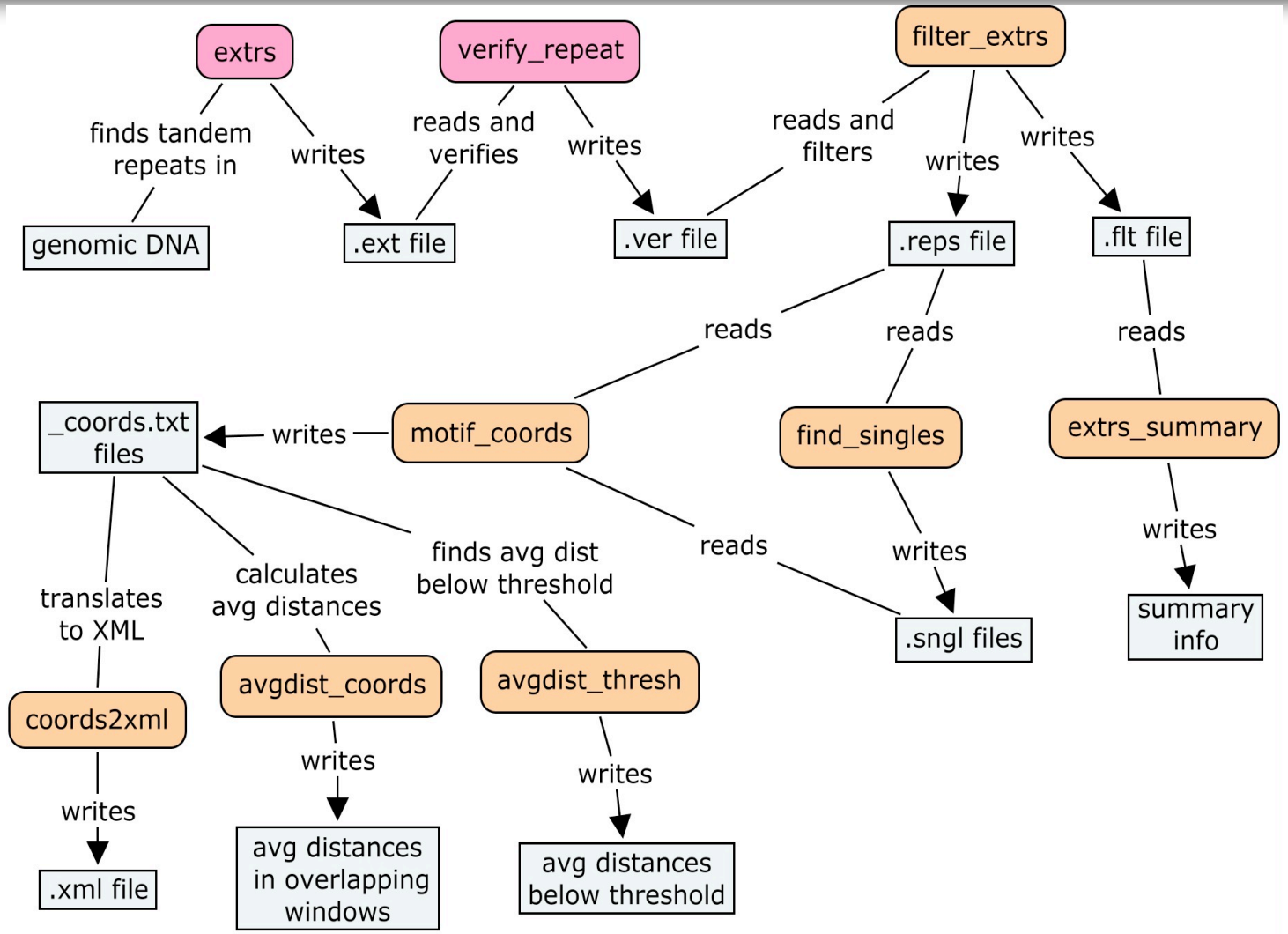
- Pseudocode is used to write the logical flow of a script, without worrying about precise syntax

Concept Maps and CmapTools

- From wikipedia.org:
  - Concept mapping is a technique for visualizing the relationships between different concepts. A concept map is a diagram showing the relationships between concepts. Concepts are connected with labeled arrows, in a downward-branching hierarchical structure.

- `CmapTools` is a freely available package that is very easy to use to build Concept maps
  - Download from http://cmap.ihmc.us/
  - This page uses a Concept Map to explain Cmap Tools!
  - You can create detailed maps that represent complex relationships in a very short time

Concept Map Example: tandem repeats



Pseudocode: Basic Script Design

- You know the importance of Experimental Design… The same holds true for software design.

- Before you begin writing a script, flesh out the logic using flowcharts or concept maps.
- Before writing your Perl code, write the script logic using pseudocode, a blend of natural language and programming language.
  - Pseudocode focuses on logic without worrying about programming language syntax.

- Pseudocode Example:

```
if sequence is valid
    compute GC content and output
    search for promoter sequence
else
    display error message
end if
```

Homework

- Study for Perl Quiz on Thursday

- For more help with Perl functions, see
- http://perlmeme.org/howtos/perlfunc/
- You can also check http://stackoverflow.com

- Read Chapter 5 in "Beginning Perl". You may SKIP or SKIM sections:
  - Posix and Unicode Classes
  - Changing Delimiters
  - Inline Comments
  - Inline Modifiers
  - Lookaheads and Lookbehinds