

Unix, Perl and BioPerl

III:

Sequence Analysis with Perl - Modules and BioPerl

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Sequence analysis with Perl Modules and BioPerl

- Regular expressions
- Hashes
- Using modules
- Library for WWW access in Perl (LWP)
- Common Gateway Interface Class (CGI)
- GD and SVG graphics libraries
- BioPerl (SeqIO, SearchIO)

Objectives

- Start to take advantage of the power of Perl's regular expressions
- Start to use modules to extend the power of Perl's core functions
- Start to use BioPerl modules for sequence analysis

Regular expressions

- “a pattern to be matched against a string”
- found in Unix, Perl, and elsewhere
- used in Perl for matching and substitution
- Regexp's use lots of special characters
- Perl example: extracting human fasta headers

```
@hdrs = grep (/^>.*(human|homo)/i, @lines);
```

- ^ beginning of word anchor
- .
- *
- | logical 'OR'
- i pattern is case insensitive

Some uses of regular expressions

- biological applications you've seen:
 - sequence motifs
 - transcription factor binding sites
- other biological applications:
 - parsing GenBank and BLAST reports
 - reformatting data from a file (ex: EMBOSS output)
 - extracting references from a manuscript

Writing a regular expression

- Describe the pattern in English
- What part of match do you want to extract?
- Translate into Perl (see below)

[A-Z] any capital letter

[0-9]* ≥ 0 numbers

\s+ ≥ 1 space chars

[^A] anything but 'A'

\d{3} 3 digit numbers

\bword\b word anchor

ATG/i ATG or atg

ATG/g all ATG's

escaped characters: ***** **\.**

\+ **\|** **** **\/** **\#** **\"**

Regex examples for GenBank files

- ORGANISM Mus musculus

```
if (/ (ORGANISM\s*) (.*) /)
    { $org = $2; }
```

- VERSION NM_007553.1 GI:6680793

```
if (/VERSION (.*) GI:(\d*)/)
    { $ver = $1; $gi = $2; }
```

- CDS 357..1541

```
if (/ (CDS\s*) (\d*) (\.\.) (\d*) /)
    { $start = $2; $end = $4; }
```

Hashes

- pairs of scalar data represented as a lookup table
- a hash can be created all at once:
`%hash = (key1, value1, key2, value2, etc.)`
- examples: creating `%translate` and `%gi`

```
%translate = (  
  "ATG", "M",           "GGT", "G",  
  "CAT", "H",           "TAG", "*",  
); # etc. . .
```

```
$codon = "ATG";  
print "ATG is the codon for $translate{$codon}";  
#     ATG is the codon for M  
# In general, $hash{key} = value;
```

key	value
ATG →	M
GGT →	G
CAT →	H
TAG →	*

Hashes (cont.)

- a hash can also be created one key/value pair at a time:

```
$hash{key} = value
```

- Example: given a file of GI numbers and sequence names (ex: NM_001202 BMP4 ...), create %gi2seq

```
while (<IN>
{
    @f = split (/ /, $_);
    $gi2seq{$f[0]} = $f[1];
    print "GI:$f[0] is $gi2seq{$f[0]}.";
}
```

```
# example:      GI: NM_001202 is BMP4.
```

```
# To separate out keys and values:
```

```
@mykeys = keys(%gi2seq);
```

```
@myvalues = values(%gi2seq);
```

Introduction to modules

- "a unit of software reuse"
- adds a collection of commands related to a specific task
- core modules vs. other modules
- see <http://www.cpan.org/> to find documents and downloads, etc.

Using modules

- Before using a module that you installed yourself,
`use lib '/full/path/to/module' ;`
- For all modules,
`use module_name ;`
- Example:
`# full path to directory with GD.pm`
`use lib '/home/elvis/modules' ;`
`use GD; # The .pm is optional`

Object-oriented Perl

- objects are module-specific references to data
- a module can describe multiple objects
 - Bio::SeqIO::fasta
 - Bio::SeqIO::GenBank
- -> send information about the data
- example of creating an object and performing methods on it:

```
$seqs = Bio::SeqIO->new(-file => "$inFile",  
    '-format' => 'Fasta');    # makes a SeqIO object  
  
$seqobj = $seqs->next_seq(); # makes a Seq object  
  
$rawseq = $seqobj->seq();  
  
$rev_comp = $seqobj->revcom->seq();
```

LWP: fetch WWW documents

- To automate WWW access
- LWP::Simple - procedural interface to LWP
- Example of usage:

```
use LWP::Simple;
$url = "http://www.whatever.com/data.html";
$page = get($url);
if ($page)
    { # do something }
else    { print "Problems getting $url"; }
```

Human and mouse RefSeq promoter extractor at WIBR

Extract genomic sequence near transcription start and/or stop.

Paste in list of RefSeq IDs (one per line, ex: NM_007376):

```
NM_198943
NM_182905
NM_024796
NM_152486
NM_015658
NM_198317
NM_032129
NM_021170
NM_005101
NM_017891
NM_153254
```

Species: human mouse

Upstream regulatory region:

NT upstream of transcription start:

NT downstream of transcription start:

Downstream regulatory region:

NT upstream of transcription stop:

NT downstream of transcription stop:

Sequence options:

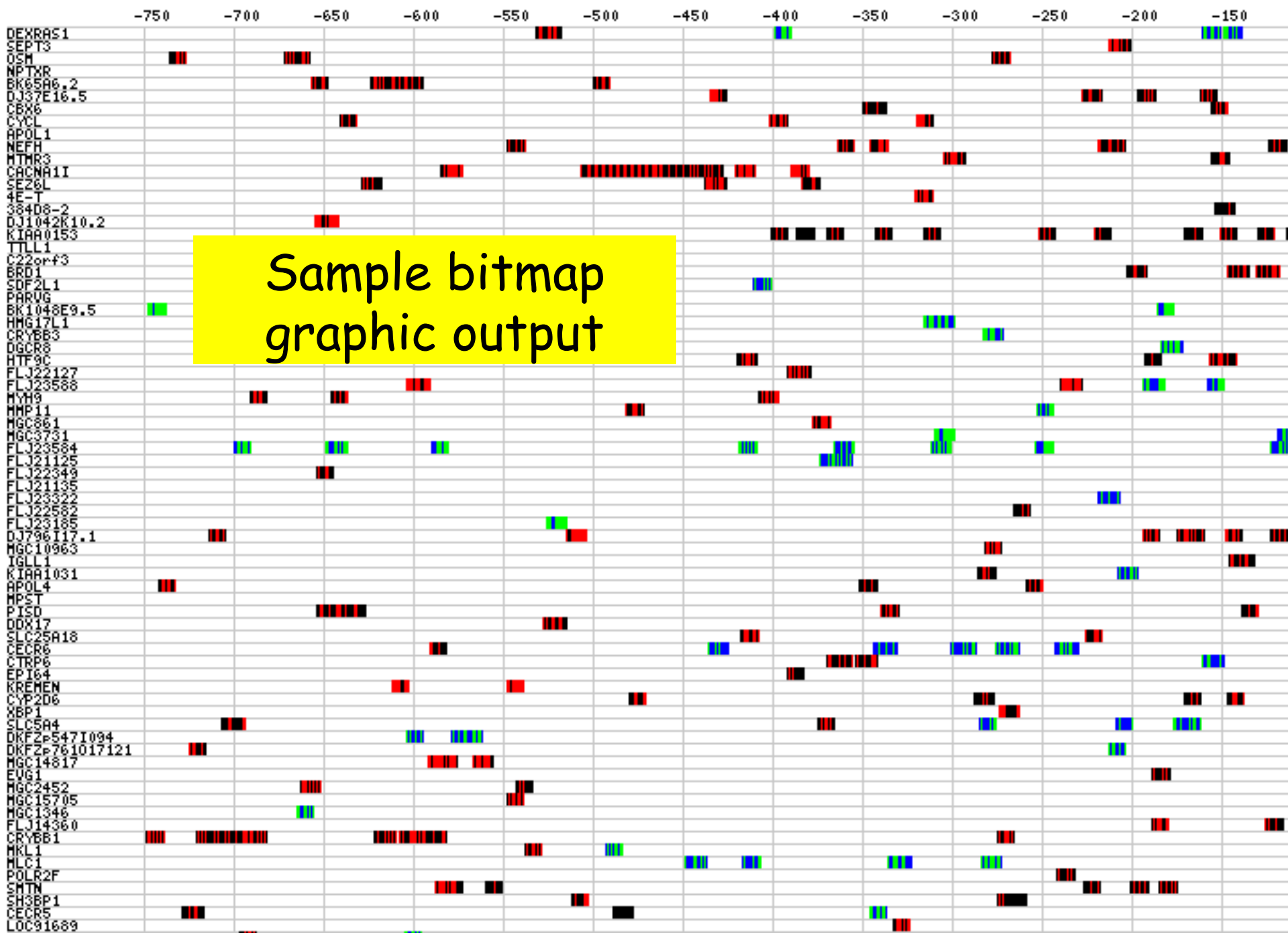
- Repeats in lower case
- Mask repeats as Ns
- All uppercase

[Description of the algorithm](#)

CGI: run scripts from the WWW

- gets input from HTML forms
- stdout writes document in browser
- execution controlled by server configuration
- example of usage:

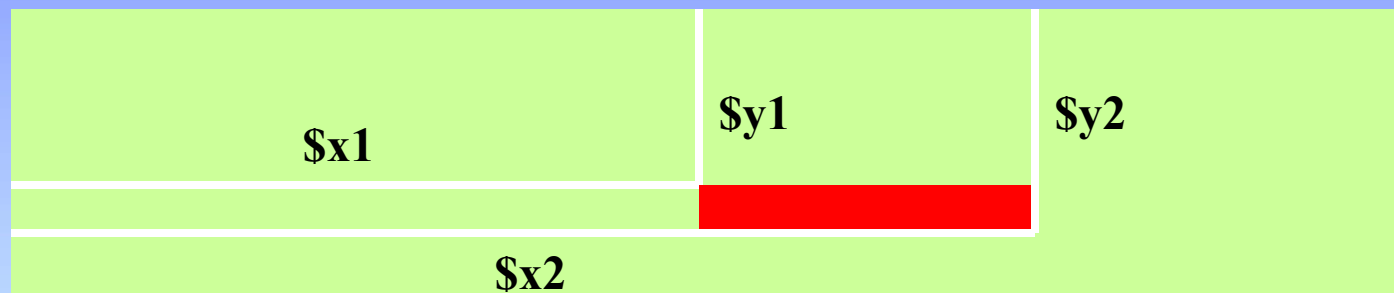
```
use CGI qw(:standard);          # import :group shortcuts
$input = new CGI;
print $input->header('text/html');
# print content here
print $input->end_html;
```



Sample bitmap graphic output

GD: generate bitmap graphics

- GD generates figures (png, gif(?)) from rectangles, polygons, circles, lines, and text
- For all methods, position is in pixels from top left corner of figure



- method examples:

```
$img->filledRectangle($x1, $y1, $x2, $y2, $red);
```

```
$img->string(gdSmallFont, $x, $y, $text, $green);
```

SVG: generate vector graphics

- Vector graphics
 - images are made up of objects
 - magnification maintains resolution
 - figures can be edited in Illustrator
- based on XML (text)
- SVG images can be viewed in a web browser BUT require a free plug-in

(<http://www.adobe.com/svg/>)

BioPerl

- modules designed to simplify the writing of bioinformatics scripts
- uses objects (references to a specific data structure)
- Seq: main sequence object
 - available when a sequence file is read

```
$seqs = Bio::SeqIO->new('-file' =>  
"inputFileName", '-format' => 'Fasta');  
$seqobj = $seqs->next_seq();
```

BioPerl's SeqIO module

- sequence input/output
- formats: Fasta, EMBL, GenBank, swiss, SCF, PIR, GCG, raw
- parse GenBank sequence features
 - CDS, SNPs, Region, misc_feature, etc.
- sequence manipulation:
 - subsequence, translation, reverse complement

Using SeqIO

```
$in = Bio::SeqIO->new(-file => "$in", '-format' => 'Fasta');
$out = Bio::SeqIO->new(-file => ">>$out", '-format' =>
    'Genbank');

while ($seqobj = $in->next_seq())
{
    $out->write_seq($seqobj);      # print sequence to $out
    print "Raw sequence:", $seqobj->seq();
    print "Sequence from 1 to 100: ", $seqobj->subseq(1,100);
    print "Type of sequence: ", $type = $seqobj->alphabet();
    if ($type eq "dna")
    {
        $rev_comp = $seqobj->revcom->seq();
        print "Reverse complement: $rev_comp";
        print "Reverse complement from 1 to 100";
            $seqobj->revcom->subseq(1, 100);
    }
}
}
```

Parsing BLAST reports with SearchIO

- best BioPerl blast parser

```
use Bio::SearchIO;
$report = new Bio::SearchIO(-file=>"$inFile",
    -format => "blast");
while($result = $report->next_result)
{
    while($hit = $result->next_hit)
    {
        while ($hsp = $hit->next_hsp)
        {
            print "Hit=", $hit->description, "\t",
                "PercentID=", $hsp->percent_identity, "\n";
        }
    }
}
```

Summary: Perl and BioPerl

- Regular expressions
- Hashes
- Using modules
- Library for WWW access in Perl (LWP)
- Common Gateway Interface Class (CGI)
- GD and SVG graphics libraries
- BioPerl (SeqIO, SearchIO)

Summary: Bioinformatics tools

- individual applications (Blast, Genscan, etc.):
 - web
 - command line
- analysis packages: EMBOSS, etc.
- Unix tools
- Perl tools
 - core commands
 - core modules
 - BioPerl and other "add-on" modules

Demo scripts on the web site

get_web_data.pl	use LWP to automate web file access
draw_figure.pl	draw a PNG figure using the GD module
draw_figure_SVG.pl	draw a figure with vector graphics
fastaToGenbank.pl	sequence conversion
genbank_parse.pl	parse GenBank sequence features
manipulate_seq.pl	manipulate a sequence
blast_parse.pl	parse BLAST output files using BioPerl's SearchIO

Exercises

- 1: Parsing a file of multiple BLAST reports
- 2: Manipulating a GenBank file with BioPerl and creating a PNG image
- 3: Setting up a web-based search script