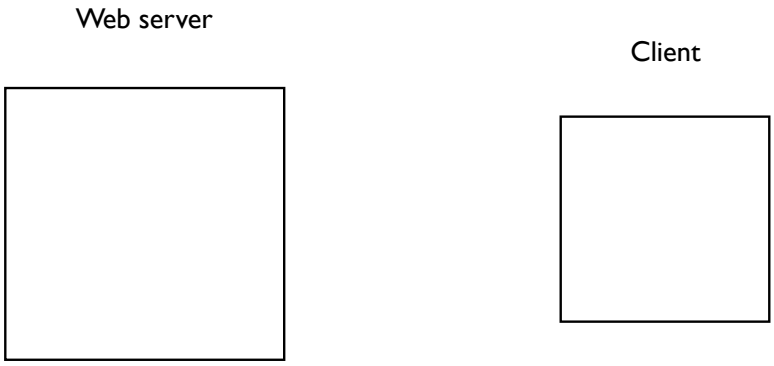
Web programming with CGI.pm

Server-Client Architecture and CGI

- Wikipedia summary: The Common Gateway Interface (CGI) is a standard method for web servers to delegate the generation of web pages to executable files. Such files are known as CGI scripts; they are programs, often stand-alone applications, usually written in a scripting language.
- Until now, you have run scripts from the command line.
  - Your scripts are somewhere like your home directory or ~/perl/ etc and the output is printed on the screen or in a file
- In web programming, scripts go somewhere like Public/username/cgi-bin/ on a web server
  - The output of scripts is HTML and is sent to a browser running on a client machine where it is rendered as a web page.
  - This set up allows you to create dynamic web pages that are generated in response to user input e.g. if the user enters a search query on a form on a web page, the search terms are sent to a CGI script which runs on the web server and returns the results of the search as HTML which is then displayed in the web browser exactly as if it was a web page.

This is better explained as a diagram, which we will draw together



Setting up and executing CGI scripts

- Here's how you set up CGI scripts on our computers
  - In Finder, use Connect to Server... (command - k)
  - Select Public
  - Navigate to the directory with your_username/cgi-bin/
  - Save your CGI scripts in this directory.
  - This directory has to be executable by 'other'. You can use `chmod +755 <dirname>` to do this.
  - Your web scripts also have to be executable by 'other'. You can do this with `chmod +755 myscript.pl`

A CGI Script that Creates Plain Text

```
#!/usr/bin/perl
# file: plaintext.pl

 print "Content-type: text/plain\n\n";

 print "When that Aprill with his shoures soote\n";
 print "The droghte of March hath perced to the roote,\n";
 print "And bathed every veyne in swich licour\n";
 print "Of which vertu engendered is the flour...\n";
```

http://mckay.cshl.edu/cgi-bin/course/plaintext.pl

A CGI Script that Creates HTML

```
#!/usr/bin/perl
# file: chaucer.pl

 print "Content-type: text/html\n\n";

 print "<html><head><title>Chaucer</title></head><body>\n";
 print "<h1>Chaucer Sez</h1>\n";

 print "When that Aprill with his shoures soote<br>\n";
 print "The droghte of March hath perced to the roote,<br>\n";
 print "And bathed every veyne in swich licour<br>\n";
 print "Of which vertu engendered is the flour...<p>\n";

 print "<cite>-Geoffrey Chaucer</cite>\n";
 print "<hr>\n";
 print "</body></html>\n";
```

http://mckay.cshl.edu/cgi-bin/course/chaucer.pl

A CGI Script that Does Something Useful

A CGI script can do anything a Perl script can do, such as opening files and processing them. Just print your results to STDOUT.

```
#!/usr/bin/perl -w
# file: process_cosmids.pl
use strict;

my @GENES   = qw/act-1 dpy-5 unc-13 let-653 skn-1 C02D5.1/;
my $URL     = 'http://www.wormbase.org/db/gene/gene?name=';

print "Content-type: text/html\n\n";
print "<html><head><title>Genes</title></head><body>\n";
print "<h1>Genes</h1>\n";
print "<ol>\n";

for my $gene (@GENES) {
  print qq(<li><a href="$URL$gene">$gene</a>\n);
}

print "</ol>\n";
print "</body></html>\n";
```

http://mckay.cshl.edu/cgi-bin/course/process_genes.pl

Creating Fill-Out Forms

HTML includes about a half-dozen elements for creating fill-out form elements. A form must begin with <FORM> and end with </FORM>:

Code:

```
<form action="http://stein.cshl.org/cgi-bin/test-cgi.pl" method="POST">
  Choose a Motif:
    <input type="text"   name="motif" value="TATTAT"> <br>
    <input type="submit" name="search" value="Search!"> <br>
</form>
```

Result:

Choose a Motif: TATTAT

Search!

Creating Fill-Out Forms II

The <FORM> Tag

Attributes:

action (required)
CGI script to submit contents of form to.

method (required)
Submission method. Depends on CGI script. One of:
- POST
- GET

encoding
Required by certain scripts that accept file uploads. One of:
- application/x-www-form-urlencoded
- multipart/form-data

Creating Fill-Out Forms III

<INPUT> Elements

Used for text fields, buttons, checkboxes, radiobuttons. Attributes:

type
Type of the field. Options:
- submit
- radio
- checkbox
- text
- password
- hidden
- file

name
Name of the field.

value
Starting value of the field. Also used as label for buttons.

size
Length of text fields.

checked
Whether checkbox/radio button is checked.

Creating Fill-Out Forms IV

Examples:

```
<input type="text"   name="motif1" value="TATTAT">

<input type="checkbox" name="motif2" value="TATTAT">

<input type="radio" name="motif3" value="TATTAT" checked>
<input type="radio" name="motif3" value="GGGGGG">

<input type="hidden" name="settings" value="PRIVACY MODE ON">

<input type="submit" name="search" value="SEARCH!">
```

Creating Fill-Out Forms V

<SELECT> Element

Used to create selection lists.

Attributes:

name
Name the field.

size
Number of options to show simultaneously.

multiple
Allow multiple options to be shown simultaneously.

<OPTION> Element

Contained within a >SELECT> element. Defines an option:

```
>option>I am an option</option>
```

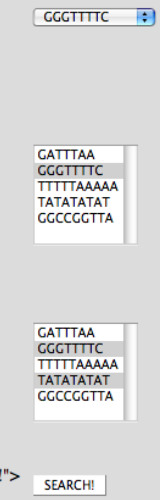
Attributes:

selected
Whether option is selected by default.

value
Give the option a value different from the one displayed.

Creating Fill-Out Forms VI

```
<select name="motif1">
  <option>GATTTAA</option>
  <option selected>GGGTTTTC</option>
  <option>TTTTTAAAAA</option>
  <option>TATATATAT</option>
  <option value="Tricky!">GGCCGGTTA</option>
</select>

<select name="motif2" size=6>
  <option>GATTTAA</option>
  <option selected>GGGTTTTC</option>
  <option>TTTTTAAAAA</option>
  <option>TATATATAT</option>
  <option>GGCCGGTTA</option>
</select>

<select name="motif3" size=6 multiple>
  <option>GATTTAA</option>
  <option selected>GGGTTTTC</option>
  <option>TTTTTAAAAA</option>
  <option>TATATATAT</option>
  <option>GGCCGGTTA</option>
</select>

<input type="submit" name="search" value="SEARCH!">
```



Creating Fill-Out Forms VII

<TEXTAREA> Elements

Used to create big text elements.

Attributes:

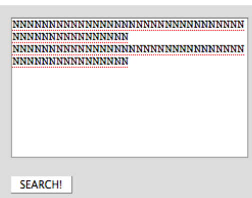
name
name of field

rows
rows of text

cols
columns of text

wrap
type of word wrapping

```
<textarea name="sequence" rows=10 cols=30>
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
</textarea>

<input type="submit" name="search" value="SEARCH!">
```



What is CGI.pm?

1. Standard module in Perl distribution (>= 5.004)
2. Emits correct HTTP headers
3. HTML shortcuts
4. Parses CGI parameters
5. "Sticky" form fields
6. Creates & processes cookies
7. File uploads

Make HTML Beautiful

CGI.pm defines functions that emit HTML. The page is easier to read and write than raw HTML*

```
<h1>
  Eat Your Vegetables
</h1>
<ol>
  <li>peas</li>
  <li>broccoli</li>
  <li>cabbage</li>
  <li>
      peppers
         <ul>
            <li>red</li>
            <li>yellow</li>
            <li>green</li>
         </ul>
    </li>
<ol>
<hr>
```

```
#!/usr/bin/perl
# Script: vegetables1.pl

use CGI ':standard';

print header,
   start_html('Vegetables'),
   h1('Eat Your Vegetables'),
   ol(
      li('peas'),
      li('broccoli'),
      li('cabbage'),
      li('peppers',
         ul(
            li('red'),
            li('yellow'),
            li('green')
            )
         ),
      ),
   hr,
   end_html;
```

* if you speak Perl!

http://mckay.cshl.edu/cgi-bin/course/vegetables.pl

Make HTML Concise

Tag Functions are Distributive

```
print li('hi','how','are','you')

    <LI>hi how are you</LI>

@items=('hi','how','are','you'); print li(\@items)

    <LI>hi</LI>
    <LI>how</LI>
    <LI>are</LI>
    <LI>you</LI>

print li(['hi','how','are','you'])

    <LI>hi</LI>
    <LI>how</LI>
    <LI>are</LI>
    <LI>you</LI>
```

Add HTML Attributes Using Hash References

```
%opts=(-type=>'square'); @items=('hi','how','are','you'); print li(\%opts,\@items)

    <LI TYPE="square">hi</LI>
    <LI TYPE="square">how</LI>
    <LI TYPE="square">are</LI>
    <LI TYPE="square">you</LI>

print li({-type=>'square'},['hi','how','are','you'])

    <LI TYPE="square">hi</LI>
    <LI TYPE="square">how</LI>
    <LI TYPE="square">are</LI>
    <LI TYPE="square">you</LI>
```

```
#!/usr/bin/perl
# Script: vegetables2.pl

use CGI ':standard';

print header,
  start_html('Vegetables'),
  h1('Eat Your Vegetables'),
  ol(
    li(['peas',
       'broccoli',
       'cabbage',
       'peppers' .
       ul(['red','yellow','green']),
       'kolrabi',
       'radishes'])
    ),
  hr,
  end_html;
```

http://mckay.cshl.edu/cgi-bin/course/vegetables2.pl

Using CGI.pm for the Genes Script

```
#!/usr/bin/perl -w
# file: process_genes2.pl

use strict;
use CGI ':standard';

my @GENES   = qw/act-1 dpy-5 unc-13 let-653 skn-1 C02D5.1/;
my $URL     = 'http://www.wormbase.org/db/gene/gene?name=';

my @list_items;
for my $gene (@GENES) {
  push @list_items,a({-href=>"$URL$gene"},$gene);
}

print header(),
    start_html('Genes'),
    h1('Genes'),
    ol(
       li(\@list_items)
       ),
    end_html;
```

http://mckay.cshl.edu/cgi-bin/course/process_genes2.pl

Setting & Retrieving CGI Parameters

You can set and retrieve CGI parameters easily. In these examples, the CGI field string is:

banana=yellow&squash=green&tomato=red&tomato=green

Retrieve a Single-Valued Field Named "Tomato":

Call *param()* with the name of the field and assign it to a scalar.

```
my $banana_color = param('banana');
# yields "yellow"
```

This works for both GET and POST types, including *multipart/form-data*.

Retrieve a Multi-Valued Field Named "Tomatoes":

Call *param()* with the name of the field and assign it to an array:

```
my @tomatoes = param('tomato');
# yields ('red','green')
```

Finding out What Parameters are Available

Call *param()* without any arguments. Will return the names of each of the parameters:

```
my @fields = param;
# yields ('banana','squash','tomato')
```

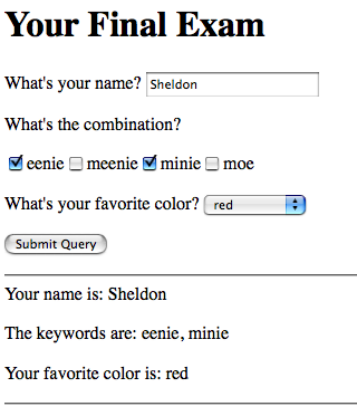
Setting Single- and Multivalued Fields:

```
param(-name=>'tomato',  -value=>'red');
param(-name=>'tomatoes',-value=>['red','green','blue']);
```

Parameters set in this way will be used as default values for fill-out form fields and hidden fields.

A Simple Form

```
#!/usr/bin/perl
# file: final_exam.pl

use CGI ':standard';

print header;
print start_html('Your Final Exam'),
   h1('Your Final Exam'),
   start_form,
   "What's your name? ",textfield(-name=>'first_name'),
   p,
   "What's the combination?",
   p,
   checkbox_group(-name   => 'words',
                  -values  => ['eenie','meenie','minie','moe'],
                  -defaults => ['eenie','minie']),
   p,
   "What's your favorite color? ",
   popup_menu(-name   => 'color',
              -values => ['red','green','blue','chartreuse']),
   p,
   submit,
   end_form,
   hr;

if (param()) {
   print
      "Your name is: ",param('first_name'),
      p,
      "The keywords are: ",join(", ",param('words')),
      p,
      "Your favorite color is: ",param('color'),
      hr;
}

print end_html;
```



Form Generating Functions I

Run *perldoc CGI* for details:

start_form
: Start the form (returns the <form> tag with default attributes).

end_form
: End the form by returning the </form> tag.

textfield(-name=>$name,-value=>$starting_value)
: Create a text field.

password_field(-name=>$name,-value=>$starting_value)
: Create a password field.

textarea(-name=>$name,-value=>$starting_value,-rows=>$rows,-cols=>$cols)
: Create a multiline text input area.

checkbox(-name=>$name,-value=>$value,-checked=>1)
: Create a single checkbox.

checkbox_group(-name=>$name,-value=>\@values,-default=>\@on)
: Create a group of checkboxes sharing the same name. @values gives the list of checkbox values, and @on gives the list of those that are initially on.

Form Generating Functions II

radio_group(-name=>$name,-value=>\@values,-default=>$on)
Create a group of radio buttons sharing the same name. @values gives the list of radio values, and $on indicates which one is on to start with.

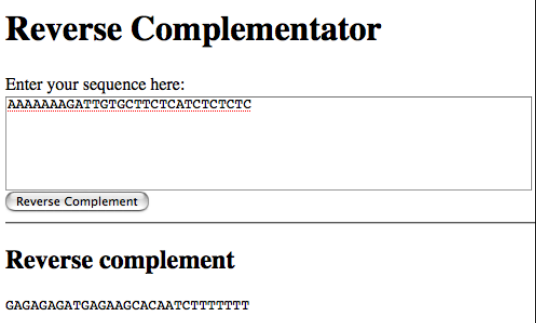
popup_menu(-name=>$name,-value=>\@values,-default=>$on)
Create a popup menu. @values gives the list of items, and $on indicates which one is initially selected.

scrolling_list(-name=>$name,-value=>\@values,-default=>$on)
Create a scrolling list. @values gives the list of items, and $on indicates which one (if any) is initially selected.

submit(-name=>$name,-value=>$value)
Creates a submit button. $value optionally sets the button label.

```
#!/usr/bin/perl
# file: reversec.pl

use CGI ':standard';

print header;
print start_html('Reverse Complementation'),
  h1('Reverse Complementator'),
  start_form,
  "Enter your sequence here:",br,
  textarea(-name=>'sequence',-rows=>5,-cols=>60),
  submit('Reverse Complement'),
  end_form,
  hr;

if ( param ) {
  my $sequence = param('sequence');

  my $reversec = do_reverse($sequence);
  $reversec    =~ s/(.{60})/$1\n/g;  # do word wrap

  print h2('Reverse complement');
  print pre($reversec);
}

print end_html;

sub do_reverse {
  my $seq = shift;
  $seq =~ s/\s//g;              # strip whitespace
  $seq =~ tr/gatcGATC/ctagCTAG/; # complement
  $seq = reverse $seq;          # and reverse
  return $seq;
}
```

A reverse complementation script



File Uploading

HTML: <INPUT TYPE="FILE"> CGI.pm: filefield()

Annoying complication:
You have to start the form with start_multipart_form() rather than start_form().

Let's modify reversec.pl to support file uploads:

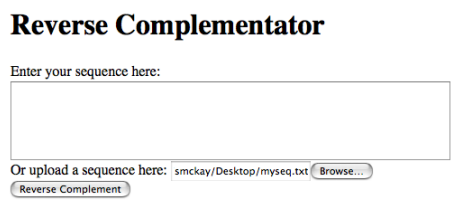
• First part (script too big for one page), print the form

```
#!/usr/bin/perl
# file: sequpload.pl

use CGI ':standard';

print header;
print start_html('Reverse Complementation'),
  h1('Reverse Complementator'),
  start_multipart_form,
  "Enter your sequence here:",br,
  textarea(-name=>'sequence',-rows=>5,-cols=>60),br,
  'Or upload a sequence here: ',filefield(-name=>'uploaded_sequence'),
  submit('Reverse Complement'),
  end_form,
  hr;
```

sequpload.pl continued…

```
if ( param ) {

  my $sequence;

  # look for the uploaded sequence first...
  if ( my $upload = param('uploaded_sequence') ) {
    print h2("Reverse complement of $upload");

    while (my $line = <$upload>) {
      chomp $line;
      next unless $line =~ /^[gatcnGATCN]/;
      $sequence .= $line;
    }

  } else { # ... not found, so read it from the text field
    print h2('Reverse complement');
    $sequence = param('sequence');
  }

  $reversec = do_reverse($sequence);
  $reversec    =~ s/(.{60})/$1\n/g;  # do word wrap
  print pre($reversec);
}

print end_html;

sub do_reverse {
  my $seq = shift;
  $seq =~ s/\s//g;              # strip whitespace
  $seq =~ tr/gatcGATC/ctagCTAG/; # complement
  $seq = reverse $seq;          # and reverse
  return $seq;
}
```

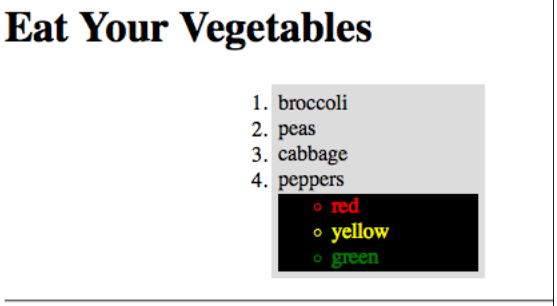
If param() returns true, that means that we have some user input



http://mckay.cshl.edu/cgi-bin/course/sequpload.pl

Adding Cascading Stylesheets

```
#!/usr/bin/perl -w
# Script: veggies_with_style.pl
use CGI ':standard';

my $css = <<END;
<style type="text/css">
 li.yellow { color: yellow }
 li.green  { color: green  }
 li.red    { color: red    }
 ol {
   background-color: gainsboro;
   padding: 5px;
   margin-left: 200px;
   width: 150px;
 }
 ul { background-color: black }
</style>
END

print header,
    start_html( -title => 'Vegetables',
                -head  => $css );
print
    h1('Eat Your Vegetables'),
    ol(
       li(['broccoli', 'peas', 'cabbage']),
       li('peppers',
          ul(
             li({-class => 'red'},'red'),
             li({-class => 'yellow'},'yellow'),
             li({-class => 'green'},'green')
             )
          ),
       ),
    hr,
    end_html;
```



http://mckay.cshl.edu/cgi-bin/course/veggies_with_style.pl

External stylesheet

```
#!/usr/bin/perl -w
# Script: veggies_with_style.pl
use CGI ':standard';

my $css = '/css/veggies.css';

print header,
    start_html( -title => 'Vegetables',
                -style  => $css );
print
    h1('Eat Your Vegetables'),
    ol(
       li(['broccoli', 'peas', 'cabbage']),
       li('peppers',
          ul(
             li({-class => 'red'},'red'),
             li({-class => 'yellow'},'yellow'),
             li({-class => 'green'},'green')
             )
          ),
       ),
    hr,
    end_html;
```

http://mckay.cshl.edu/cgi-bin/course/veggies_with_style2.pl

CGI Exercises
Problem #1

Write a CGI script that prompts the user for his or her name and age. When the user presses the submit button, convert the age into "dog years" (divide by 7) and print the result.

Problem #2

Accept a DNA sequence and break it into codons.

Extra credit: Translate the codons into protein.