BIOL 404: Molecular Evolution
Neutrality Tests III

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Sampling scale follow-up
For MK test, need multiple samples for multiple lineages:

<table>
<thead>
<tr>
<th>Locus</th>
<th>dN</th>
<th>dS</th>
<th>dN/dS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

For dN/dS test can have few or many samples in few or many lineages:

**Interspecific dN/dS analysis:**
compared human and chimpanzee to each other
and to mouse/rat and analyzed synonymous vs
non-synonymous differences

**Intraspecific dN/dS analysis:**
compared 20 European-American and 19 African-
American individuals and analyzed synonymous
vs non-synonymous polymorphisms

Nielsen et al 2005

Among locus tests
“The effects of natural selection are generally
locus-specific, whereas migration, drift and
inbreeding are expected to have relatively
uniform effects across the entire genome”

- Storz & Nachman 2003

**Genomic scans for selection and Fst outlier tests**

**Statistical outlier examples:**

Fst outlier test: example 1
**Benthic vs Limnetic morphs of sympatric Whitefish**

White bars: simulated expectation
Grey bars: observed data

Campbell and Bernatchez 2004
Fst outlier test: example 2
Analysis of >25,000 human Single Nucleotide Polymorphisms (SNPs) identified 174 candidate genes under selection

Fst outlier test: example 2
Akey et al 2002

Table 4. Biological Processes of Candidate Selection Genes

<table>
<thead>
<tr>
<th>Process Description</th>
<th>High Fst</th>
<th>Low Fst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of terms</td>
<td>123</td>
<td>26</td>
</tr>
<tr>
<td>Synthesis</td>
<td>10 (8.1%)</td>
<td>2 (7.7%)</td>
</tr>
<tr>
<td>Cell adhesion</td>
<td>2 (1.6%)</td>
<td>2 (1.6%)</td>
</tr>
<tr>
<td>Cell-cell signaling</td>
<td>4 (3.1%)</td>
<td>3 (2.3%)</td>
</tr>
<tr>
<td>Neoplasia and tumorigenesis</td>
<td>73 (57.9%)</td>
<td>15 (57.9%)</td>
</tr>
<tr>
<td>Protein synthesis</td>
<td>4 (3.1%)</td>
<td>2 (2.3%)</td>
</tr>
<tr>
<td>Signal transduction</td>
<td>21 (16.7%)</td>
<td>7 (26.9%)</td>
</tr>
<tr>
<td>Cell growth and maintenance</td>
<td>40 (30.5%)</td>
<td>5 (15.4%)</td>
</tr>
<tr>
<td>Metabolism and transport</td>
<td>43 (34.0%)</td>
<td>5 (15.4%)</td>
</tr>
<tr>
<td>Transcription</td>
<td>9 (7.1%)</td>
<td>2 (2.3%)</td>
</tr>
<tr>
<td>Transport</td>
<td>12 (9.4%)</td>
<td>2 (2.3%)</td>
</tr>
<tr>
<td>Developmental processes</td>
<td>10 (8.1%)</td>
<td>3 (2.1%)</td>
</tr>
<tr>
<td>Chromosome and mitotic evolution</td>
<td>3 (2.4%)</td>
<td>5 (2.8%)</td>
</tr>
<tr>
<td>Replication control of gene expression</td>
<td>21 (16.7%)</td>
<td>4 (15.4%)</td>
</tr>
<tr>
<td>Replication control of other genes</td>
<td>11 (8.8%)</td>
<td>1 (3.1%)</td>
</tr>
<tr>
<td>Replication control of expression</td>
<td>11 (8.8%)</td>
<td>1 (3.1%)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (0.8%)</td>
<td>0 (0.0%)</td>
</tr>
</tbody>
</table>

Fst outlier test: example 3
Geographic samples of Plasmodium falciparum

Resistance genes
Neutral genes
Confidence intervals

Fst outlier test: example 3
Anderson et al 2005

Other non-Fst genomic scans for selection
Geographic samples of Plasmodium falciparum
dhfr - a gene involved in drug resistance

After your genomic scan...
Stinchcomb and Hoekstra 2007

Nair et al 2003
Parallelism and Convergence

**Convergence:** evolution of similar phenotypes in divergent taxa

Parallelism:
evolution of similar phenotypes in similar taxa OR more specifically from similar ancestral state to similar derived state due to similar selection pressures

Parallelism and Convergence
Parallelism and Convergence

In reality it can be difficult to stringently discriminate between parallel and convergent evolution (and some argue that we shouldn’t bother). Both can be used as evidence for selection.

Parallelism and Convergence

*Pitx1* (expression) involvement in pelvic reduction

Shapiro et al 2006

Parallelism and Convergence

How common is it to see the same genetic mechanism underlying adaptations within lineages and between lineages?

Shapiro et al 2006

Reading for next week

* Arendt and Reznick 2007
  Hoekstra et al 2006
  Rompler et al 2006
  G+L pg 121-123