Making genomic testing work for you.

Dr. Tom Lawlor
Director, Research and Development
Holstein Association USA
What people are saying...

- Columbia Pictures “employing a sophisticated computer-based analysis”
- Sony Pictures “for anyone who has ever dreamed of taking on the system.”
- Roger Ebert - Chicago Sun-Times
  “mind-numbing statistical theories”
  “war between intuition and statistics”
  “What the number crunchers demonstrated is that a computer can assemble a team better than human instinct.”
- Joe Morgenstern - Wall Street Journal
  “Never before, though, has the power of math added up to such electrifying...
Genomic Testing continues to improve. Prices continue to drop

<table>
<thead>
<tr>
<th>Number Of SNPs</th>
<th>3K</th>
<th>6K</th>
<th>50K</th>
<th>770K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$43</td>
<td>$125</td>
<td>$250</td>
<td></td>
</tr>
</tbody>
</table>
## Chip size & Reliability

<table>
<thead>
<tr>
<th></th>
<th>Sire genotyped</th>
<th>Sire &amp; MGS genotyped</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3K</strong></td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td><strong>6K</strong></td>
<td>66</td>
<td>70</td>
</tr>
<tr>
<td><strong>50K</strong></td>
<td>70</td>
<td>72</td>
</tr>
<tr>
<td><strong>High Density</strong></td>
<td>72</td>
<td>73</td>
</tr>
</tbody>
</table>
Usage of different chips

Last 7 months:
79% 3K  20% 50K  1% 3K→50K

Top 200 GTPI females – August 2011
50K   169
3K    30
Imputed  1
Genomic TPI = 2211

Pedigree TPI = 2023

She received an exceptional set of genes from her parents.
How can I make efficient use of genomic testing?

• Picking elite genetics.

• Identifying low end replacements that should be culled.
Genomic testing allows you to jump ahead of the competition!
In the first 3 months of 2011
Age of females being genomic tested

73% are less than 15 months of age
<table>
<thead>
<tr>
<th>Name</th>
<th>Sire</th>
<th>Dam</th>
<th>Pro</th>
<th>Fat</th>
<th>Milk</th>
<th>Rel</th>
<th>SCS</th>
<th>PL</th>
<th>DPR</th>
<th>TYPE</th>
<th>Rel</th>
<th>UDC</th>
<th>FLIC</th>
<th>PTPI</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOLSTEIN SHOTTLE PERCELL</td>
<td>PICSTON SHOTTLE-ET TV TL</td>
<td>HOLSTEIN OMAN PETITE</td>
<td>+38</td>
<td>+51</td>
<td>+1120</td>
<td>39</td>
<td>2.75</td>
<td>3.1</td>
<td>-0.5</td>
<td>+1.71</td>
<td>38</td>
<td>+1.06</td>
<td>+1.52</td>
<td>+1931</td>
<td>9</td>
</tr>
<tr>
<td>USA 66711689 100-NA 06/01/2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN SHOTTLE AMORA-ET</td>
<td>PICSTON SHOTTLE-ET TV TL</td>
<td>HOLSTEIN GOLDWYN AMELIA-ET</td>
<td>+18</td>
<td>+48M</td>
<td>+405</td>
<td>38</td>
<td>2.70</td>
<td>2.9</td>
<td>-1.3</td>
<td>+2.87</td>
<td>37</td>
<td>+2.24</td>
<td>+1.96</td>
<td>+1912M</td>
<td>9</td>
</tr>
<tr>
<td>USA 139257409 100-NA 03/14/2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN SOCRAES YES-ET</td>
<td>VELVET-WLTV-KJ SOCRAES-ET TR TV TL</td>
<td>HOLSTEIN SHOTTLE YUP-ET TV</td>
<td>+45</td>
<td>+60G</td>
<td>+1461</td>
<td>77</td>
<td>3.06</td>
<td>3.0</td>
<td>-1.6</td>
<td>+1.52G</td>
<td>71</td>
<td>+1.14</td>
<td>+1.52</td>
<td>+1899G</td>
<td>9</td>
</tr>
<tr>
<td>USA 63855543 100-NA 12/01/2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN RAMOS GLADYS</td>
<td>RAMOS TV TL</td>
<td>HOLSTEIN OMAN GLADYS</td>
<td>+19</td>
<td>+22</td>
<td>+128</td>
<td>34</td>
<td>2.67</td>
<td>4.9</td>
<td>1.8</td>
<td>+0.92</td>
<td>33</td>
<td>+0.67</td>
<td>+1.13</td>
<td>+1885</td>
<td>9</td>
</tr>
<tr>
<td>USA 66711630 92-I 02/03/2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN PLANET OLEANA</td>
<td>ENSENADA TABOO PLANET-ET TR TV TL</td>
<td>HOLSTEIN OMAN OREO</td>
<td>+39</td>
<td>+49</td>
<td>+1160</td>
<td>36</td>
<td>2.89</td>
<td>3.8</td>
<td>0.4</td>
<td>+0.68</td>
<td>35</td>
<td>+0.62</td>
<td>-0.01</td>
<td>+1877</td>
<td>9</td>
</tr>
<tr>
<td>USA 66711678 93-NA 05/05/2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN GOLDWYN FREEZE-ET</td>
<td>BRAEDALE GOLDWYN TV TL</td>
<td>HOLSTEIN OMAN FREDA-ET</td>
<td>+16</td>
<td>+32</td>
<td>+116</td>
<td>39</td>
<td>2.71</td>
<td>2.8</td>
<td>0.2</td>
<td>+2.37</td>
<td>39</td>
<td>+1.76</td>
<td>+1.80</td>
<td>+1874</td>
<td>9</td>
</tr>
<tr>
<td>USA 65975307 100-NA 07/05/2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN PHOENIX BABBET</td>
<td>WINDY-KNOLL-VIEW PHOENIX-ET TV TL</td>
<td>HOLSTEIN CF CREST BARBIE</td>
<td>+13</td>
<td>+24M</td>
<td>+102</td>
<td>33</td>
<td>2.79</td>
<td>3.5</td>
<td>1.2</td>
<td>+1.87</td>
<td>31</td>
<td>+1.89</td>
<td>+1.31</td>
<td>+1860M</td>
<td>9</td>
</tr>
<tr>
<td>USA 68882335 96-NA 03/16/2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN RAMOS MAUREEN</td>
<td>RAMOS TV TL</td>
<td>HOLSTEIN O MAN MAURA</td>
<td>+17</td>
<td>+18</td>
<td>+112</td>
<td>38</td>
<td>2.69</td>
<td>5.7</td>
<td>1.9</td>
<td>+0.52</td>
<td>38</td>
<td>+0.52</td>
<td>+1.48</td>
<td>+1860</td>
<td>9</td>
</tr>
<tr>
<td>USA 68882274 96-I 10/04/2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN TRUMP GRACE-ET</td>
<td>JENNY-LOU SHOTTLE TRUMP-ET TV TL</td>
<td>HOLSTEIN BAXTER GRACE-ET</td>
<td>+23</td>
<td>+52M</td>
<td>+1340</td>
<td>35</td>
<td>2.82</td>
<td>2.5</td>
<td>-0.8</td>
<td>+2.11</td>
<td>32</td>
<td>+1.64</td>
<td>+1.61</td>
<td>+1857M</td>
<td>9</td>
</tr>
<tr>
<td>USA 68882302 100-NA 12/26/2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLSTEIN PLANET ZIPPER-ET</td>
<td>ENSENADA TABOO PLANET-ET TR TV TL</td>
<td>HOLSTEIN OMAN FREDA-ET</td>
<td>+29</td>
<td>+38</td>
<td>+918</td>
<td>37</td>
<td>2.93</td>
<td>3.1</td>
<td>0.5</td>
<td>+1.59</td>
<td>34</td>
<td>+1.56</td>
<td>-0.28</td>
<td>+1846</td>
<td>9</td>
</tr>
</tbody>
</table>
Some early adopters are routinely genotyping their high heifers.
Seeking top genetics

• Genotype high genetic calves and heifers.
  – Current Top 25% cutoff is: PTPI of 1700 or NM$ of $300
• Breed or flush them to a high genetic bulls.
• Genotype the offspring.
• Select the highest ones and repeat the process.
Top 200 GTPI females
August 2011

• 91 different owners

• 14 owners with 3 or more

• These breeders are very focused on producing top ranking animals.
Commercial setting

*Obtaining better replacements*

- I don’t know anything about these heifers.

- Should I genomic test them?

- Will I get an immediate payback on my genotyping costs?

- What about future gains from future descendants?
True example – 46 animals in May 2011 with NO Sire or Dam information

You know nothing about their Genetic Merit for lifetime profitability (NM$)

Without any information, they all appear the same!
Now, we know something about their genetics.
If you cull the 5 lowest animals
Average of the remaining ones is
+$52.5 higher
Is there an immediate payback?

- Each of the selected animals will generate $52.5 more per animal.

- Extra revenue from the 41 selected animals is $2,153.

  \[
  \text{Income} = 41 \text{ animals} \times $52.5 = $2,153
  \]

- Total cost to genomic test 46 animals at $43 each.

  \[
  \text{Cost} = 46 \text{ animals} \times $43 = $1,978
  \]

Yes, there is.
What about culling the lowest 10?
Average of the remaining ones is
+$99.2$ higher
The more selective you can be, the more profitable it becomes

- Each of the selected animals will generate $99.2 more per animal.

- Additional revenue from the 36 selected animals is $3,571.
  
  \[
  \text{Income} = 36 \text{ animals} \times $99.2 = $3,571
  \]

- Total cost to genomic test at $43 each is $1,978.
  
  \[
  \text{Cost} = 46 \text{ animals} \times $43 = $1,978
  \]
In the previous example, we ignored the fact that we can often identify the sire of the animal. Who's your daddy?
Identifying parents

• If the sire is genotyped, they’ll find him!

• In commercial settings where sire info is missing, 47% of the time the correct sire will be identified.

• If the sire is recorded and there’s a conflict, 90% of the time the correct sire will have been genotyped and will be identified. (otherwise, true sire has not been genotyped).
Roughly, half the time, we’ll identify the sire and our genomic prediction becomes more accurate.

Cull 5 animals out of 46

<table>
<thead>
<tr>
<th></th>
<th>Unknown Sire</th>
<th>Sire Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Additional revenue from the 41 selected animals</strong></td>
<td>$2,153</td>
<td>$2,960</td>
</tr>
<tr>
<td><strong>Cost to test all 46</strong></td>
<td>$1,978</td>
<td>$1,978</td>
</tr>
<tr>
<td><strong>Profit</strong></td>
<td>$175</td>
<td>$982</td>
</tr>
</tbody>
</table>
Animals with No pedigree information

• If you’re going to make a decision on who to keep and who to get rid of…..

Genomic test them!
What if I keep good records?

• How beneficial is genomic testing then?

• Pedigree information provides a good initial prediction of an animal’s genetic merit.
Parent Average is a good initial sort

Genetic Merit for NM$
Parent Average is a good initial sort
Genomic information adds refinement
You can cull with more reliability
Precision breeding decisions
If you’re looking to cull low end animals

• Adding the genomic information gives you a better prediction of true genetic merit.

• Very few of the culls will come from those animals that have a high parent average.

• Often, you can save genotyping dollars and improve your profitability by only genotyping the bottom animals.
Expected gains in lifetime net merit from genomic testing of cows, heifers and calves on commercial dairy farms
Assumptions of the Simulation

- 1000-cow herd plus replacement heifers
- All genomic tests were 3K @ $40 per animal
- Included genetic trend in PTAs
- Genetic parameters based on US Holsteins
- Error rate in sire identification = 15%
- Each testing plan was replicated 100 times
Strategies for Genotyping Females

- Test the whole herd
- Screen potentially elite animals for marketing
- Screen potentially inferior animals for culling
Return on Investment

• **Immediate.**
  – The increase in genetic merit of the animal is high enough to pay for the genotyping costs.

• **Future.**
  – Animal’s descendents are included.
  – Assuming each animal has 1 milking daughter within the next 4 years, and 1 granddaughter after 8 years and 1 great granddaughter after 12 years, with a discount rate of 5%.
  – Including future returns increase the value of current genetic gain by 1.65 times higher.
Results for NO pedigree information

“For heifer calves and yearling heifers that lacked pedigrees, genotyping all animals was consistently the best strategy.”

“Gains in genetic merit more than paid for the genotyping costs.”
Genotyping the bottom 50% was the more profitable strategy for 20% culling.

Revenue = $61
Cost = $40

Revenue = $49
Cost = $20

Genotyping the bottom 50% was the more profitable strategy for 20% culling.
Best genotyping strategy for 3 culling levels.

- **100% Genotyping**
- Genotype bottom 50%

<table>
<thead>
<tr>
<th>Percentage of Animals Culled</th>
<th>$0</th>
<th>$10</th>
<th>$20</th>
<th>$30</th>
<th>$40</th>
<th>$50</th>
<th>$60</th>
<th>$70</th>
<th>$80</th>
<th>$90</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>$70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>$40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td>$20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percentage of Animals Culled
Key points

- If culling opportunity is low, target the low end animals to genotype.

- As your opportunity to cull animals increases, your return on investment will also increase.
The more opportunity to cull the greater the financial gains from genomic testing.

<table>
<thead>
<tr>
<th></th>
<th>Cull 10% commercial</th>
<th>Cull 20% Repro assisted</th>
<th>Cull 40% Repro + sexed semen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added profit per selected animal</td>
<td>+$14</td>
<td>+$29</td>
<td>+$52</td>
</tr>
<tr>
<td>Profit per 100 animals</td>
<td>+$1,260</td>
<td>+$2,320</td>
<td>+$3,120</td>
</tr>
<tr>
<td>Number to Genotype</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>
Genotyping cows

• Milk production records, reproductive performance, conformation score are all good sources of information aiding in quantifying an animal’s genetic merit.

• Thus the value of genomic testing for cows is less than for heifers and cows.
**Future gains**
from genomic testing bottom 50%, and **culling 20%**

<table>
<thead>
<tr>
<th></th>
<th>No pedigree</th>
<th>Known Sire</th>
<th>Sire &amp; dam known</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves and yearlings</td>
<td>$66*</td>
<td>$29</td>
<td>$19</td>
</tr>
<tr>
<td>First lactation</td>
<td>$22</td>
<td>$15</td>
<td>$11</td>
</tr>
<tr>
<td>Third lactation</td>
<td>$21</td>
<td>$11</td>
<td>$3</td>
</tr>
</tbody>
</table>

* Genotype all calves and heifers
## Immediate return from genomic testing

**Culling bottom 20%**

<table>
<thead>
<tr>
<th></th>
<th>No pedigree</th>
<th>Known Sire</th>
<th>Sire &amp; dam known</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calves and yearlings</td>
<td>$46</td>
<td>$19</td>
<td>$9</td>
</tr>
<tr>
<td>First lactation</td>
<td>$12</td>
<td>$5</td>
<td>Break even</td>
</tr>
<tr>
<td>Third lactation</td>
<td>$11</td>
<td>Break even</td>
<td>-$7</td>
</tr>
</tbody>
</table>
Your testing program will depend upon how you will use the results.

• **Looking for elite genetics.**
  – Sort on PA, screen on 6K, validate with 50K.

• **Culling decisions.**
  – Young animals
    • 10-20% culling ---- genomic test bottom end.
    • 30% or more ---- genomic test all of them.
  – Cows
    • Return on investment is dependent on contribution of future descendents.
Future

• The financial picture for genomic testing will continue to improve in next few years as technology improves.

• Each new generation will need new DHI data, type, health records, etc. to recalibrate the genomic predictions.

• Much appreciation is given to the USDA-Animal Improvement Programs Lab for their past and future development of genomic predictions.
Thank you.

Any questions on genetics?