Phenotypes for novel functional traits of dairy cattle

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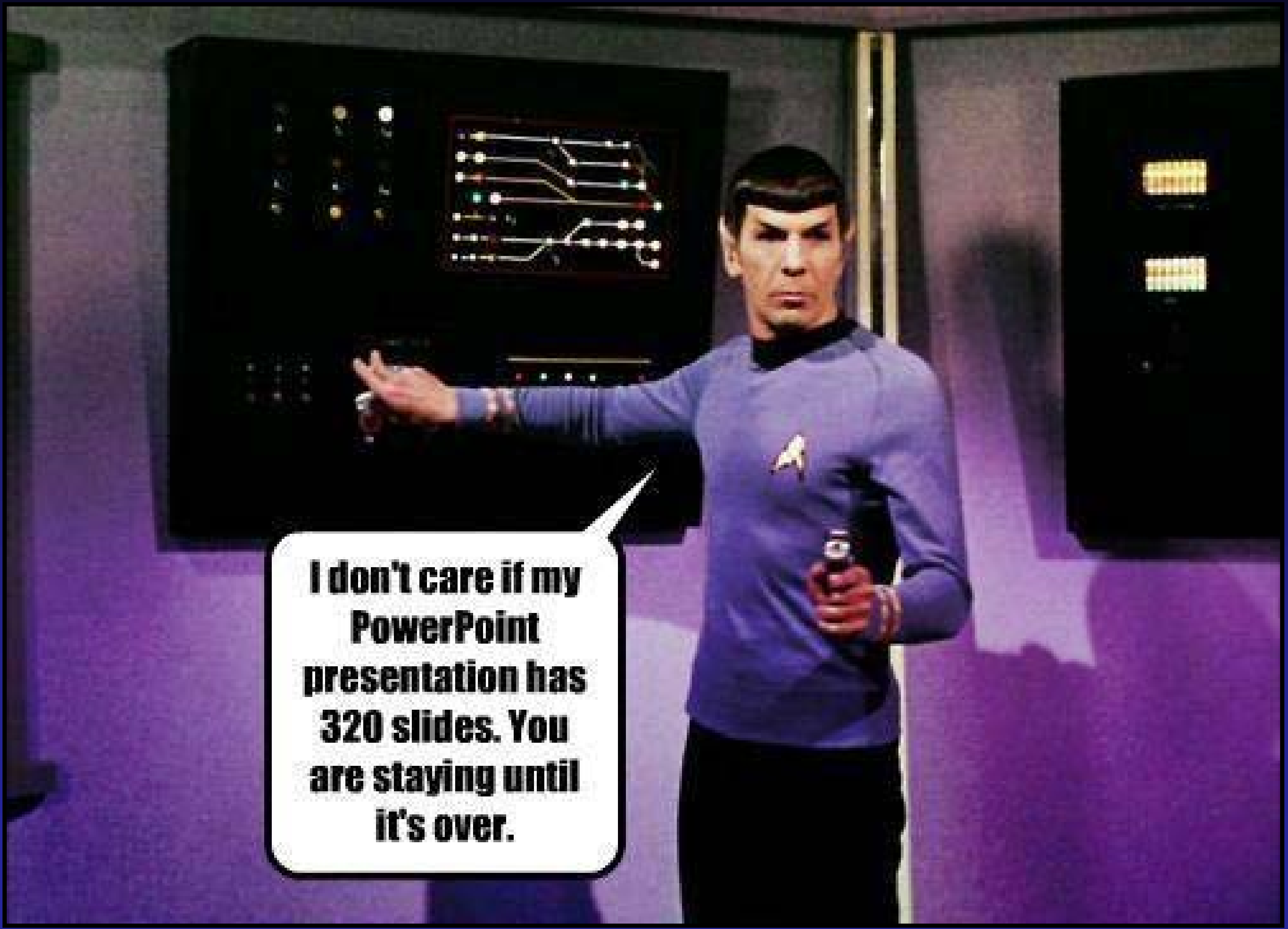
Introduction



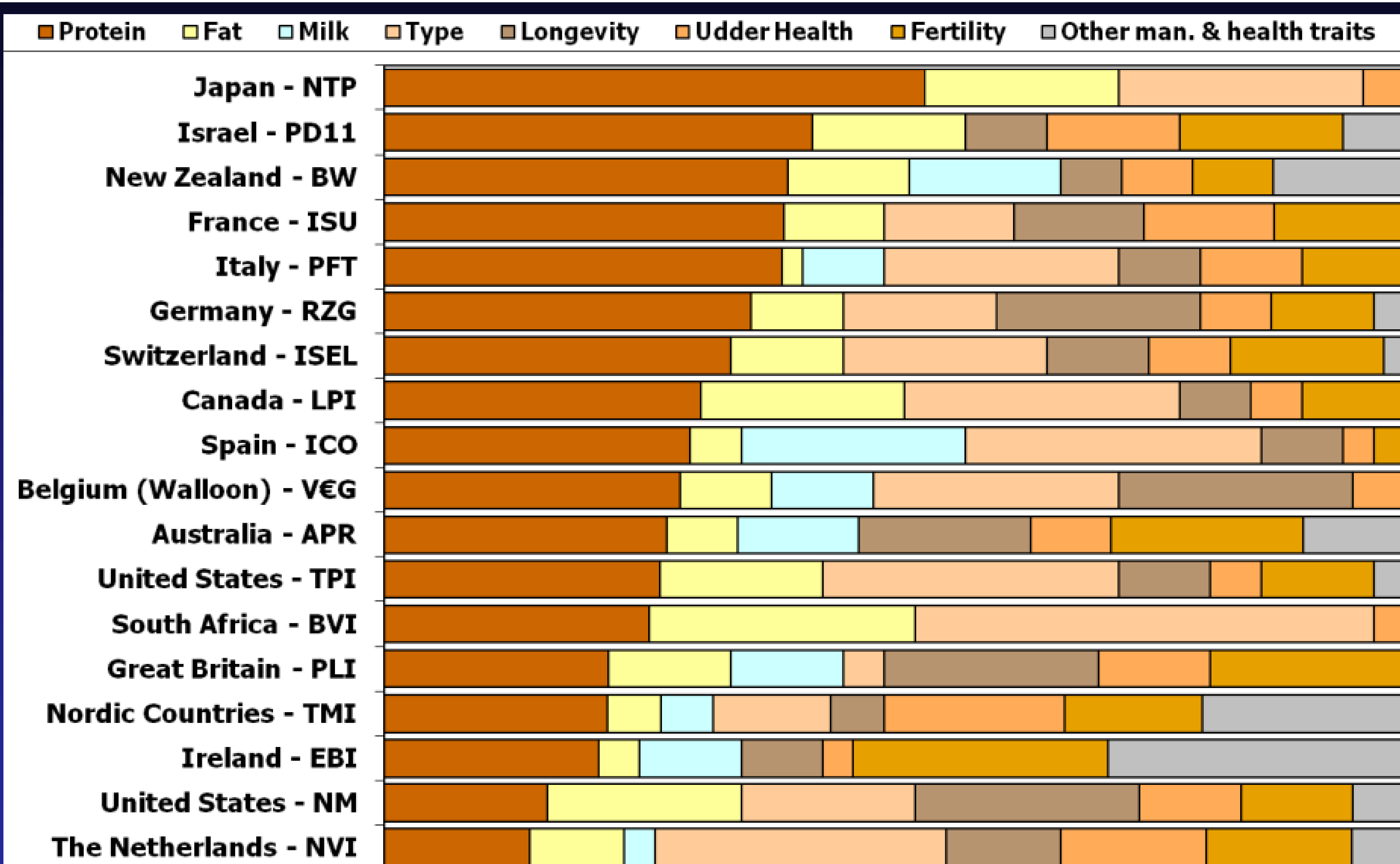
What are functional traits?

- The ICAR **Functional Traits Working Group** currently is working on:
  - General health traits
  - Female fertility
  - Feet and legs problems
  - Udder health
  - Workability

Why are functional traits important?

- Growing emphasis on functional traits
  - Economically important because they impact other traits
- Challenges with functional traits
  - Inconsistent trait definitions
  - Many have low heritabilities
  - Unclear incentives for collection

Functional traits are being used



Source: Miglior et al., 2012

Functional traits have low heritabilities

$$P = G + E$$

The percentage of total variation attributable to genetics is small.

- CA$: 0.07
- DPR: 0.04
- PL: 0.08
- SCS: 0.12

The percentage of total variation attributable to environmental factors is large:

- Feeding/nutrition
- Housing
- Reproductive management

What traits are commonly recorded?

Group	N	Traits included
Calving	4	Direct & maternal calving ease, direct & maternal stillbirth
Conformation	19	Stature, chest width, body depth, angularity, rump angle, rump width, rear leg set, rear leg rear view, foot angle, fore udder, rear udder height, udder support, udder depth, teat placement, teat length, rear teat placement, overall conformation score, overall udder score, overall feet & leg score
Fertility	5	Heifer conception rate, days to first service, cow conception rate, services per conception, and days open
Longevity	1	Direct longevity
Production	3	Milk, fat, and protein yields
Udder health	2	Milk somatic cell count, clinical mastitis
Workability	2	Milking speed, temperament

Holstein traits evaluated by the International Bull Evaluation Service (https://wiki.interbull.org/public/CoP_chapter6?action=print&rev=16).

Some traits are underutilized

- Some traits are commonly recorded, but not often genetically evaluated
  - *e.g.*, gestation length, milking speed, temperament
- Breeding objectives differ across countries
  - Not all traits equally valuable to all people
- New phenotypes can supersede old ones

Lots of genotypes are available in the US

Chip	Traditional evaluation?	Animal sex	Holstein	Jersey	Brown Swiss	Ayrshire
≥50K	Yes	Bulls	25,276	4,262	5,862	678
		Cows	22,094	1,203	136	27
	No	Bulls	51,122	4,428	806	427
		Cows	38,182	1,462	201	196
<50K	Yes	Bulls	24	13	28	14
		Cows	48,552	17,246	757	4
	No	Bulls	35,639	3,935	243	43
		Cows	294,875	34,018	1,149	677
Imputed	Yes	Cows	2,983	265	96	15
	No	Cows	1,394	50	99	16
All			520,141	66,882	9,377	2,097
						598,497

Other countries are doing genomics, too!

Country	Animals (no.)
Australia	5,314
Denmark/Finland/Sweden	23,961
France	24,313
Germany	25,624
Italy	21,041
Netherlands	23,047
Poland	3,174
Switzerland (Red Holstein)	4,194

Phenotypes may come from genotypes

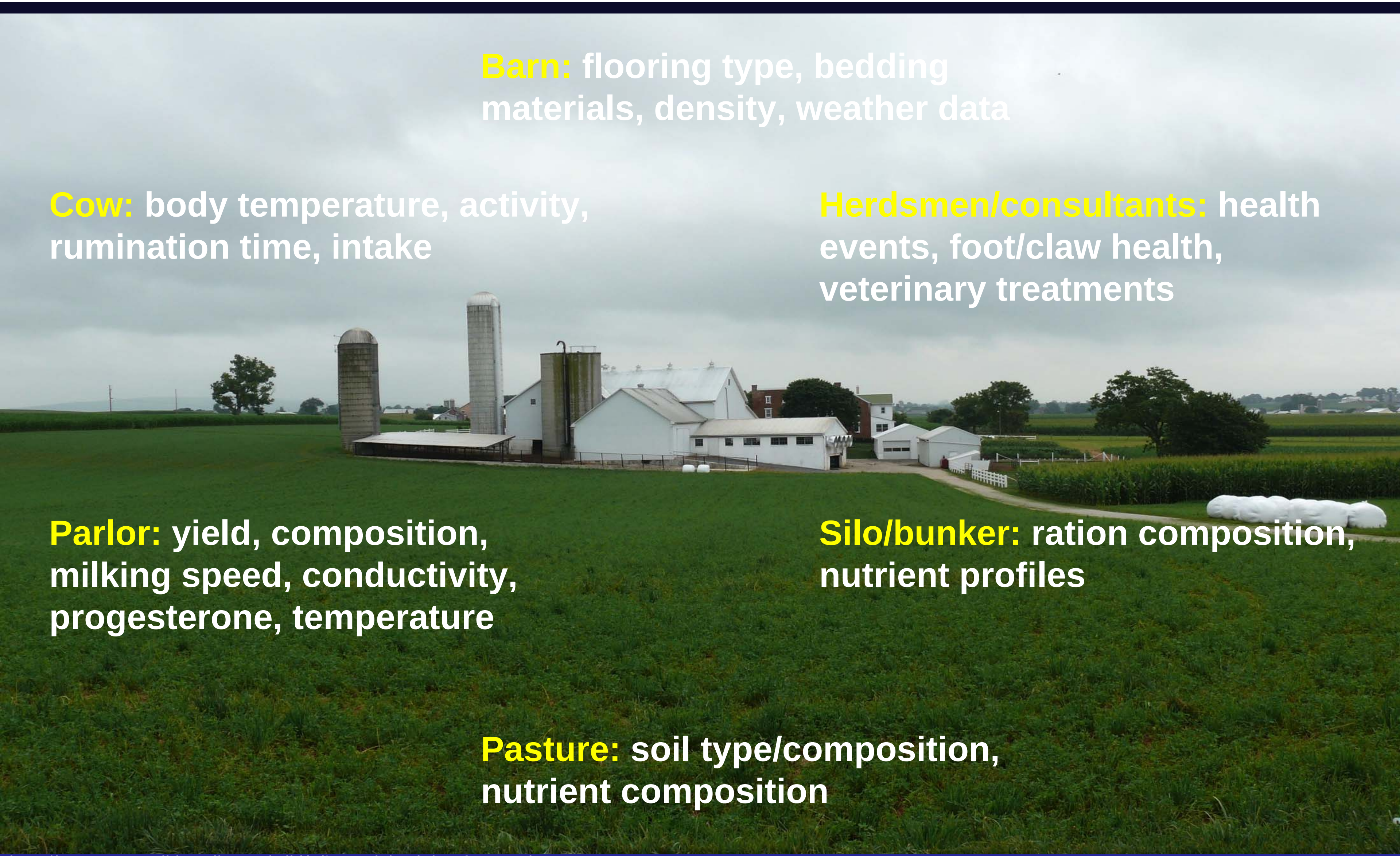
Name	Chrome	Location (Mbp)	Carrier Freq	Earliest Known Ancestor
HH1	5	62-68	4.5	Pawnee Farm Arlinda Chief
HH2	1	93-98	4.6	Willowholme Mark Anthony
HH3	8	92-97	4.7	Glendell Arlinda Chief, Gray View Skyliner
HH4	1	1.2-1.3	0.37	Besne Buck
HH5	9	92-94	2.22	Thornlea Texal Supreme
JH1	15	11-16	23.4	Observer Chocolate Soldier
BH1	7	42-47	14.0	West Lawn Stretch Improver
BH2	19	10-12	7.78	Rancho Rustic My Design
AH1	17	65.9-66.2	26.1	Selwood Betty's Commander

For a complete list, see: http://aipl.arsusda.gov/reference/recessive_haplotypes_ARR-G3.html.

Why do we need new phenotypes?

- Changes in production economics
  - Rising feed costs drive demand for increased efficiency
- Technology enables collection of new phenotypes
  - Milking speed in AMS
  - Pedometry for changes in behavior
- Better understanding of biology

Sources of novel phenotypes



Barn: flooring type, bedding materials, density, weather data

Cow: body temperature, activity, rumination time, intake

Herdsmen/consultants: health events, foot/claw health, veterinary treatments

Parlor: yield, composition, milking speed, conductivity, progesterone, temperature

Silo/bunker: ration composition, nutrient profiles

Pasture: soil type/composition, nutrient composition

http://commons.wikimedia.org/wiki/File:Amish_dairy_farm_3.jpg

Novel phenotypes studied recently

- **Claw health** (Van der Linde et al., 2010)
- **Dairy cattle health** (Parker Gaddis et al., 2013)
- **Embryonic development** (Cochran et al., 2013)
- **Immune response** (Thompson-Crispi et al., 2013)
- **Methane production** (de Haas et al., 2011)
- **Milk fatty acid composition** (Soyeurt et al., 2011)
- **Persistency of lactation** (Cole et al., 2009)
- **Rectal temperature** (Dikmen et al., 2013)
- **Residual feed intake** (Connor et al., 2013)

What do current phenotypes look like?

- Low-dimensionality
  - Usually **few** observations per lactation
  - Close **correspondence** of phenotypes with values measured
  - Easy **transmission** and **storage**

Get cow lactation records

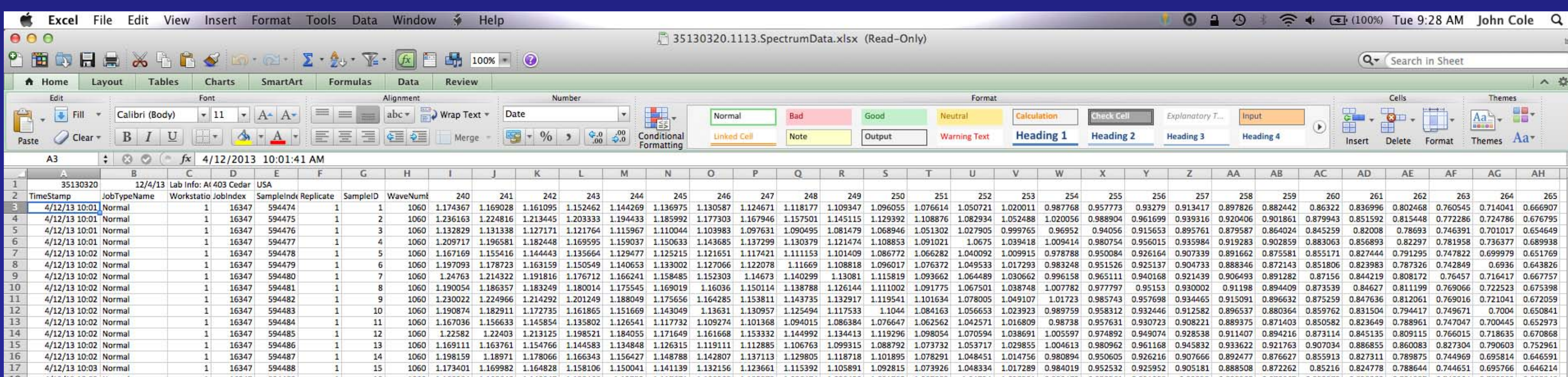
Output from "Get cow lactation records"

Cow HOCAN000008036612 key=35757290

Lac	Fresh	DIM	Herd	CtrlNo	Proc_Date	Mod_Date	LT	Mk	LI	TC	TC2	OS%	PC	Opn	DCR	Milk	DCR	Fat	DCR	Prot	DCR	SCS	Bth	NTD
1	1997/11/05	324	23361868	34	1999/04/22	2009/08/21	0	00	0	0		0	0	84	97	33142	97	1170	97	917	94	1.62	0	11
2	1998/11/16	332	23361868	34	1999/11/04	2009/08/21	0	40	0	0		0	0	79	103	33174	99	991	100	896	96	2.83	0	11
3	1999/11/26	328	23361868	34	2000/10/02	2009/08/21	0	40	0	0		0	0	151	97	34269	97	1192	97	895	95	3.23	0	10
4	2001/02/13	87	23361868	34	2001/06/01	2009/08/21	0	c0	0	7		0	0	-1	69	27738	70	996	69	736	73	3.02	0	3

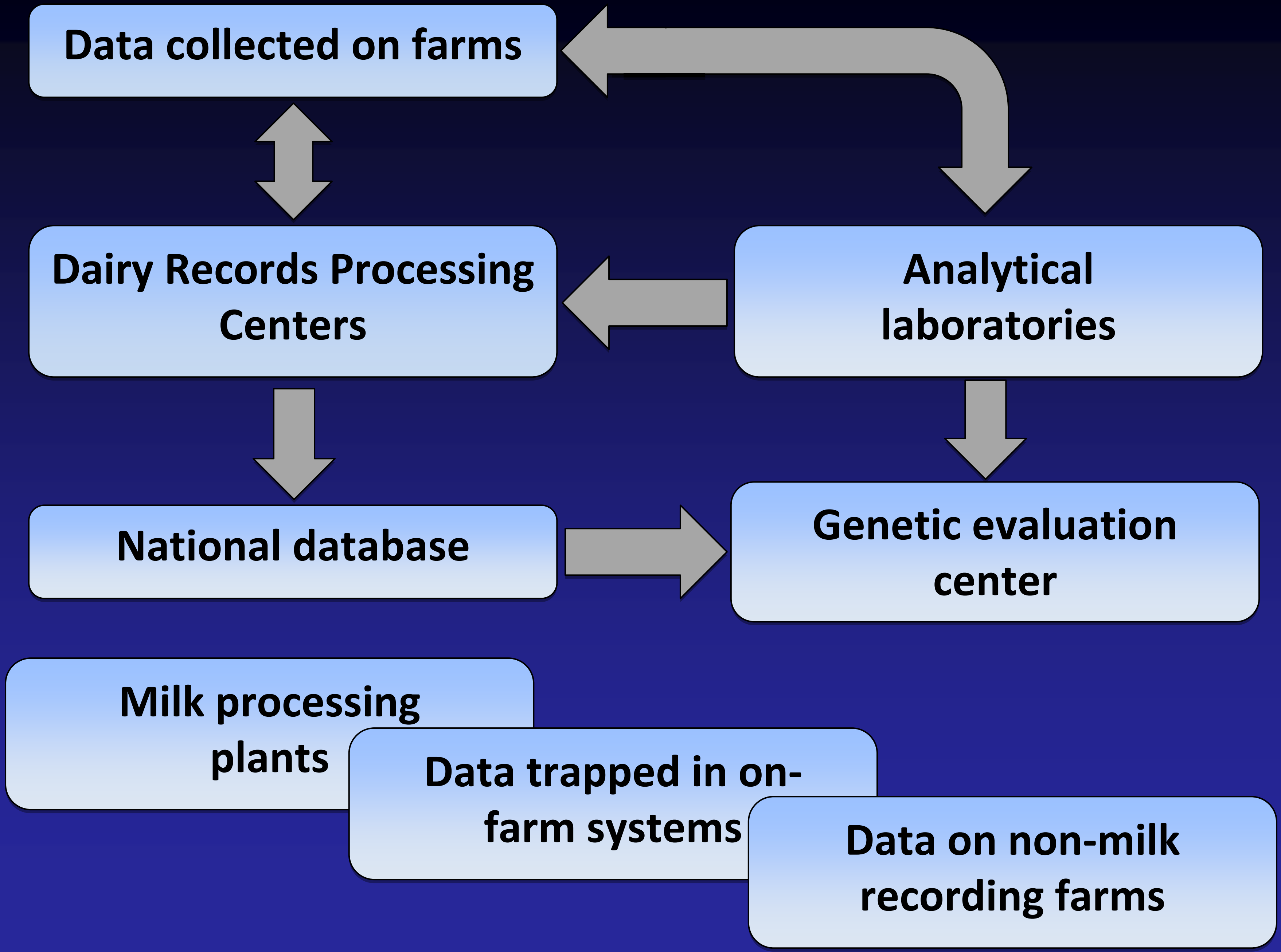
What do new phenotypes look like?

- **High dimensionality**
  - **Ex.: MIR produces 1,060 points/obs.**
  - **Disconnect between phenotype and measurement**
  - **More resources needed for transmission, storage, and analysis**

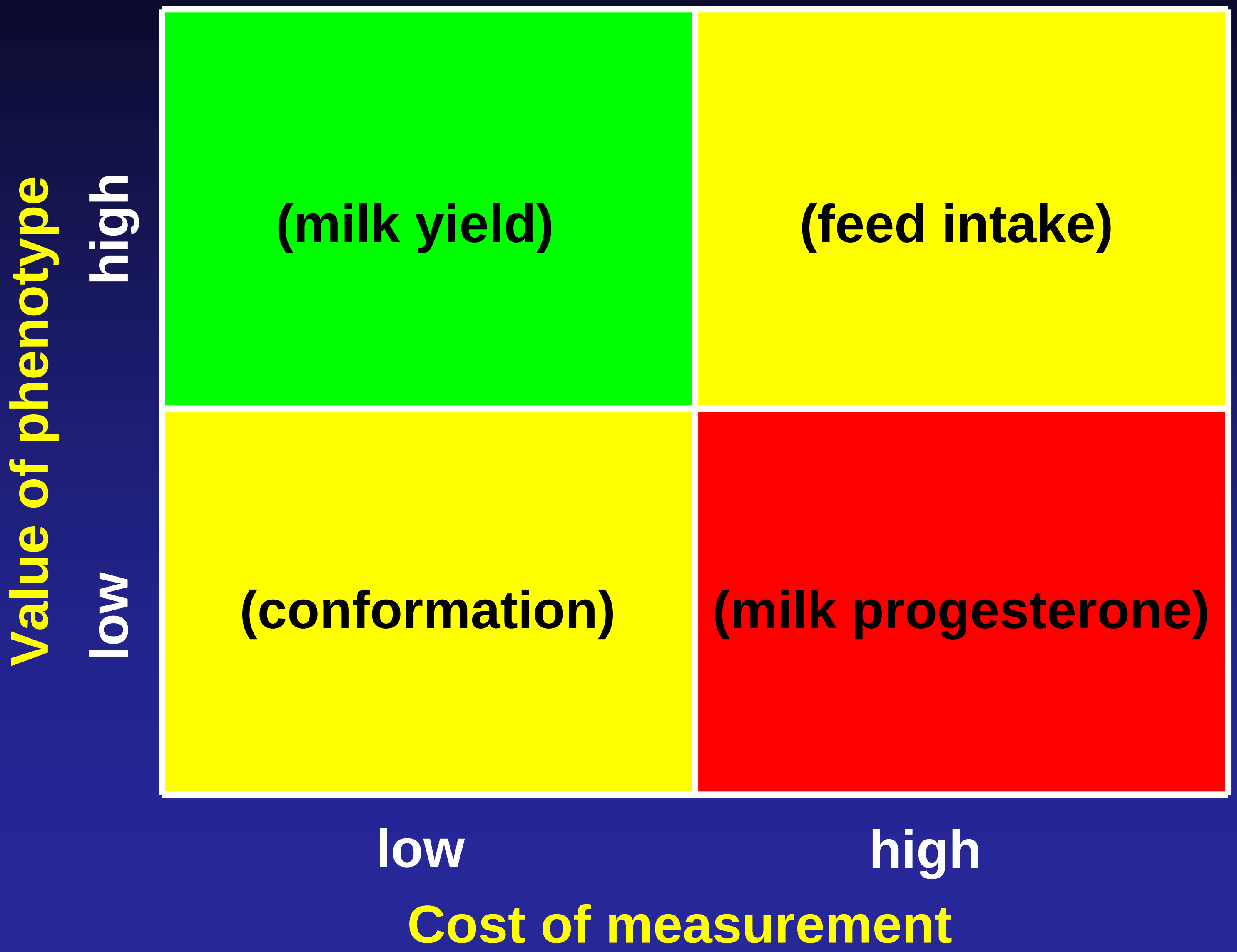


Who pays for new phenotypes?

- Costs
  - Labor and materials for recording
  - Data transmission, storage, and processing
- Benefits
  - Farmers provide data and consume services
  - Centers consume data and provide services


Data collected on farms
Dairy Records Processing Centers
Analytical laboratories
National database
Genetic evaluation center
Milk processing plants
Data trapped in on-farm systems
Data on non-milk recording farms

Cost of measurement vs. value



New phenotypes should add information

Phenotypic correlation with existing traits	Genetic correlation with existing traits: low	Genetic correlation with existing traits: high
high	Novel phenotypes include some new information	Novel phenotypes contain little new information
low	Novel phenotypes include much new information	Novel phenotypes contain some new information

What can farmers do with novel traits?

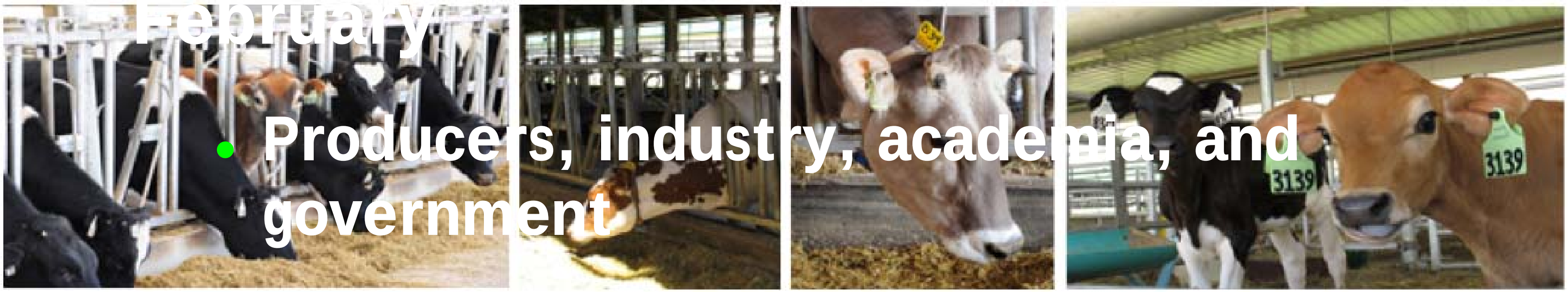
- Put them into a selection index
  - Correlated traits are helpful
- Apply selection for a long time
  - There are no shortcuts
- Collect phenotypes on many daughters
  - Repeated records of limited value
  - Genomics can increase accuracy

What can DRPCs do with novel traits?

- **Short-term** – Benchmarking tools for herd management
- **Medium-term** – Custom indices for herd management
  - Additional types of data will be helpful
- **Long-term** – Genetic evaluations
  - Lots of data needed, which will take time

What do US dairy farmers want?

- National workshop in Tempe, AZ in February



  - Producers, industry, academia, and government

  - novel phenotypes

- Foot health feed efficiency greatest interest

International challenges

- National datasets are **siloed**
- Recording standards **differ** between countries
  - ICAR standards help here
- Farmers are concerned about the **security** of their data
- Many populations are **small**
  - Low accuracies
  - Small markets

Conclusions

- New technology is enabling the collection of novel phenotypes
- New phenotypes support increased focus on economically important aspects of dairy production
- Infrastructure for moving new phenotypes from the farm to the data center is needed

Acknowledgments

- ICAR Functional Traits Working Group
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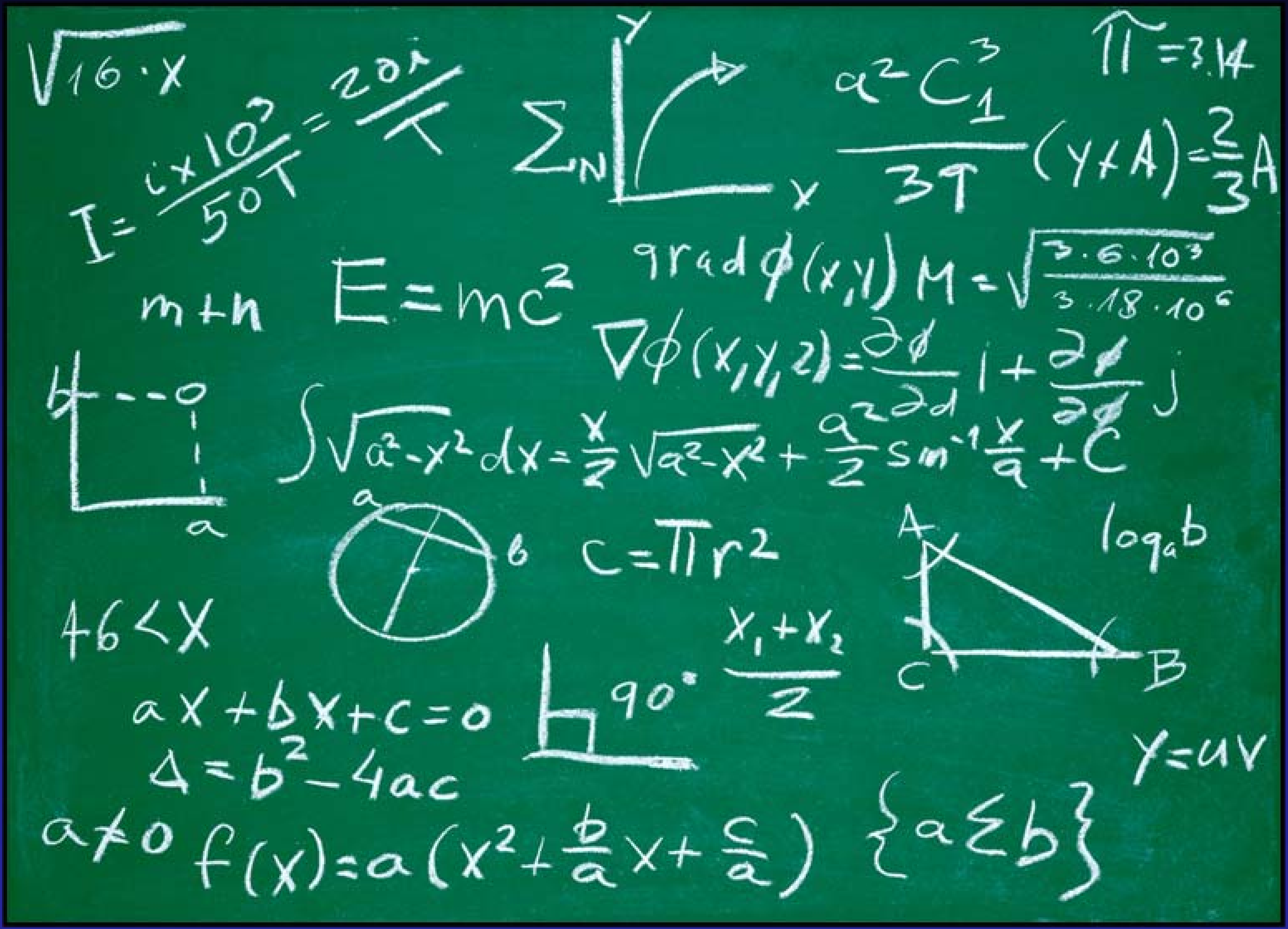
Questions?



http://gigaom.com/2012/05/31/t-mobile-pits-its-math-against-verizons-the-loser-common-sense/shutterstock_76826245/