Future of Livestock Production Research

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MARK BOGGESS, PH.D.

NATIONAL PROGRAM LEADER

FOOD ANIMAL PRODUCTION – NP101

PRIORITIES IN NP101

- Genetics and genomics
  - Functional genomics
  - Genomics as a tool for basic research
- Nutrition – nutritional efficiency
  - Basic physiology
  - Forage efficiency
- Reproductive efficiency
- Animal well-being
- Product quality
- Cooperative Programs
  - Pasture and Range
  - Manure Management
  - Human Nutrition
  - Crop genetics/genomics
  - Others: sustainability, water quality, biofuels

FUTURE OF LIVESTOCK PRODUCTION RESEARCH

- Embrace the COMPLEXITY - Larger Science – More Impact
  - Large complex interdisciplinary problems
  - Focused on SUSTAINABILITY
  - Multi-disciplinary team approaches
    - Example: PRRS Genetic Project, Great Basin Strategy
- Embracing COLLABORATION – as a competitive advantage
  - Across ARS National Programs
  - With other agencies – NIH, NSF, NIFA, others
  - Land Grant Universities
  - Industry
  - International Partners
- Focus on developing LEADERS/LEADERSHIP in NP101
  - Research community focus
  - Better communication – better reporting - larger awareness
  - Better cooperation and collaboration
  - More accountability

What is Sustainability??

ANIMAL AGRICULTURE SUSTAINABILITY

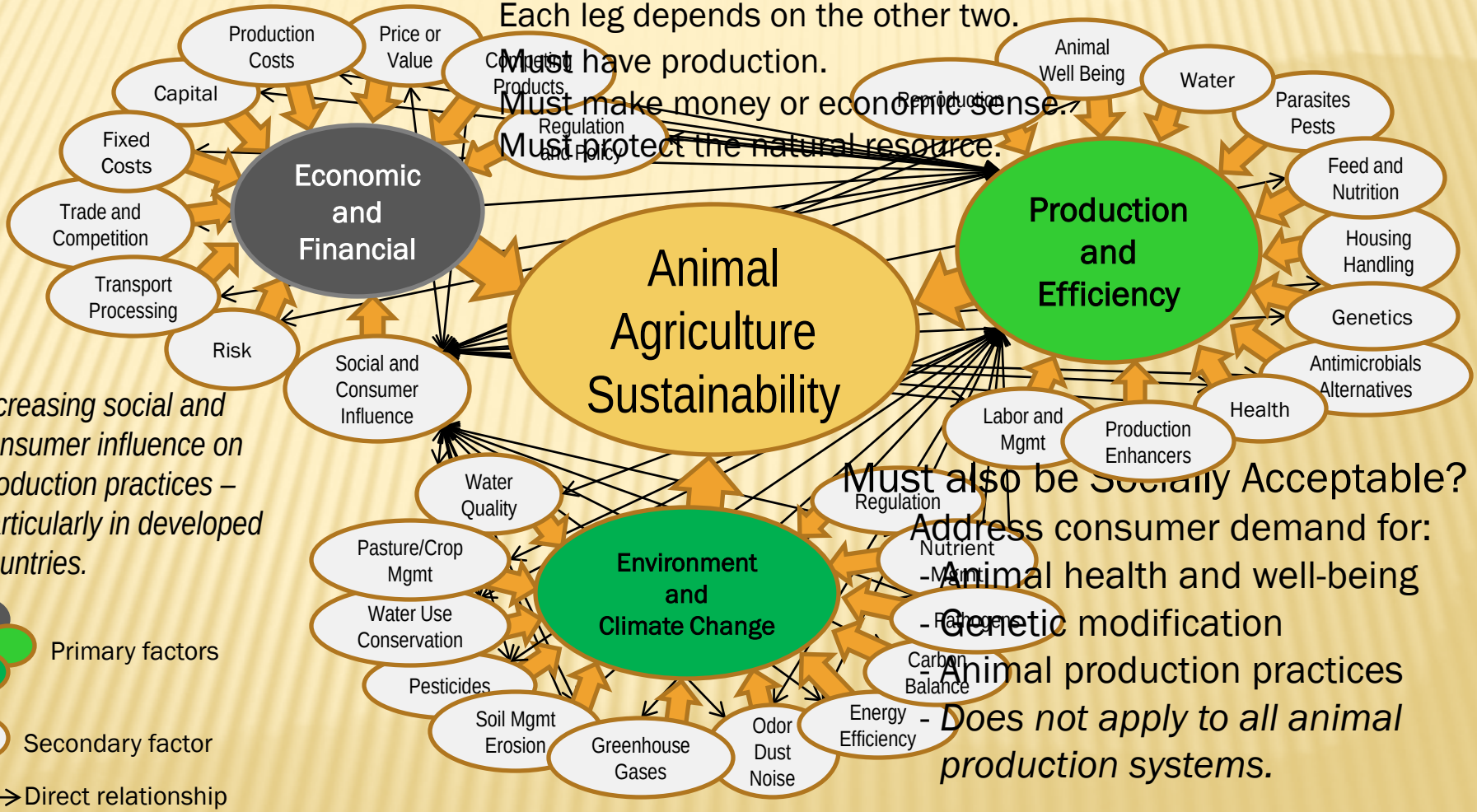
Three Legged Stool

Each leg depends on the other two.

Must have production.

Must make money or economic sense.

Must protect the natural resource.



Increasing social and consumer influence on production practices – particularly in developed countries.

Primary factors

Secondary factor

Direct relationship

Must also be Socially Acceptable?

Address consumer demand for:

- Animal health and well-being
- Genetic modification
- Animal production practices
  - *Does not apply to all animal production systems.*

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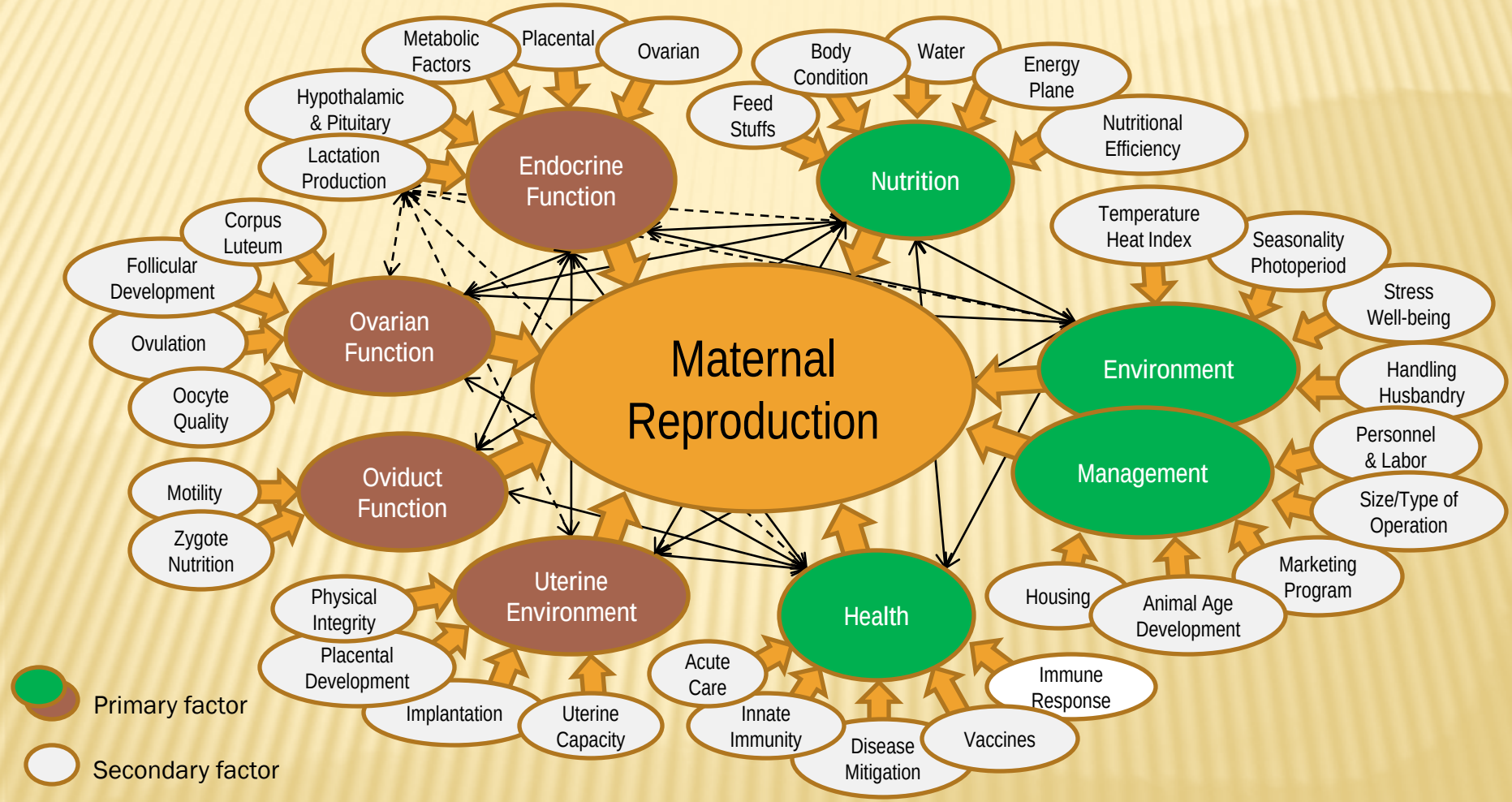
What does Complexity Look Like??

COMPLEXITY: MATERNAL REPRODUCTION



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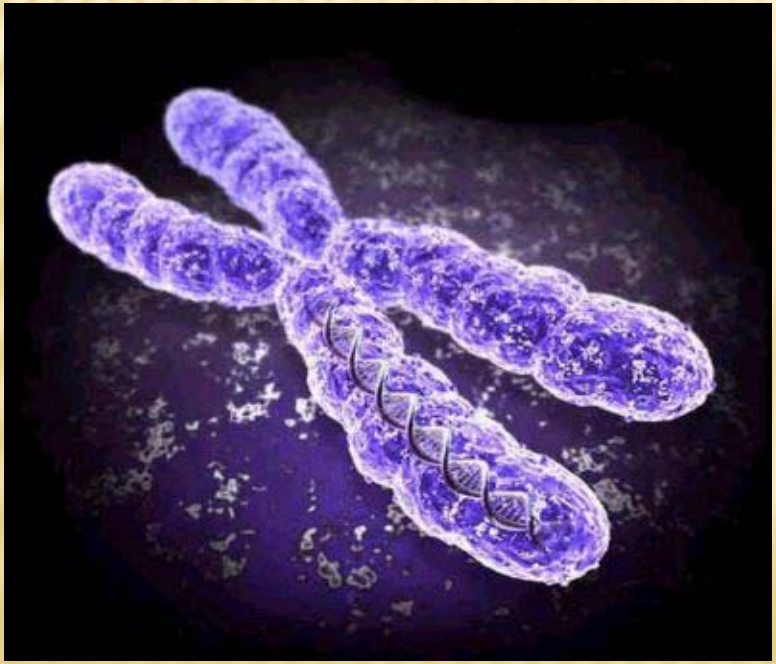
Moving From Genotype to Phenotype



MOVING FROM GENOTYPE TO PHENOTYPE

National Statistics:
- ✓National average lactation record:
  = 23,000 lbs (Holstein)
- ✓Productivity in 1950: 9,000 lbs
- ✓Focused selection
  - ✓Additive genetic variation
- ✓Improved management
- ✓Improved nutrition

Ever-Green-View My 1326-ET
Bred and Owned:
Thomas Kestell, Waldo, WI.
365 day record: 72,170 lbs
Herd average: 36,000 lbs
36 SD from the Phenotypic Mean!!
Genomic evaluation: Very Good
** But not tops in the breed

So why is this cow so productive?
- ✓Extraordinary management
- ✓Excellent phenotype – Ex 92
- ✓Very good additive genetic effects
- ✓What else?
  - Non-additive genetic effects?
  - "Environmental" interactions?

What is the biological limit??

MOVING FROM GENOTYPE TO PHENOTYPE

Genotype

?

Environment

?

Phenotype

Fundamental ... eding!

Traditional Genetics (Popula... s for populations using Phenotypes

- Non-additive

- For example dominance, epistatic interaction, maternal and paternal effects, etc…

Challenge for ... omic technologies into research focused on improved production or well-being.

Modern Genomics: Goal is to predict *individual* Phenotype from Genotype accounting for all Environmental effects

- Personalized medicine, targeted individual selection, etc…

- Accounting for Environmental effects remains a significant challenge

- examples: disease resistance, reproduction, etc…
- traditional selection is slow and less effective – little additive genetic variation
- selection for individual performance is not effective

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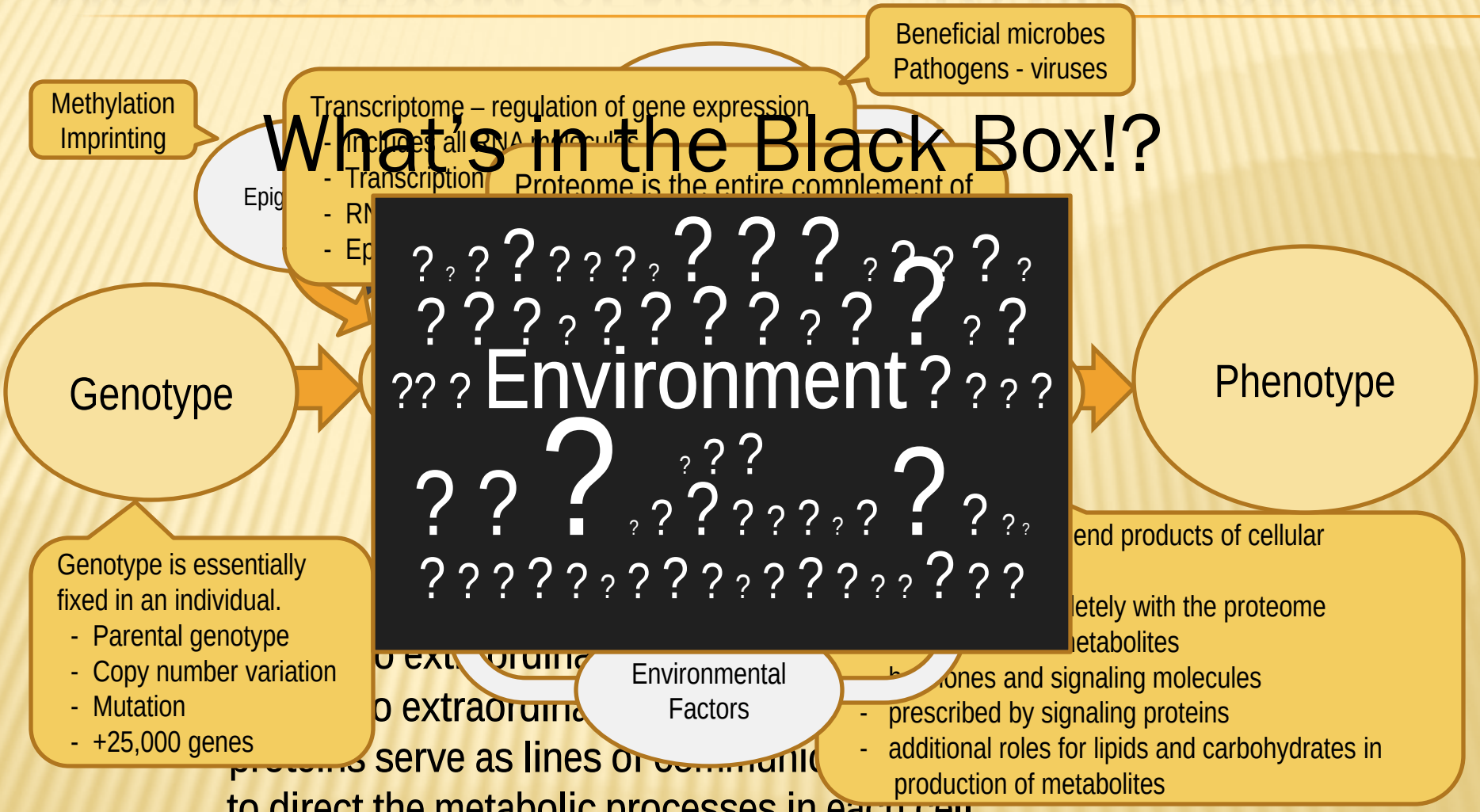
What's in the Black Box??

MOVING FROM GENOTYPE TO PHENOTYPE



All of these factors interact to create the complex and dynamic environmental effects that influence the phenotypes of all living organisms.

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MOVING FROM GENOTYPE TO PHENOTYPE

- Mastering the Environmental Component!
  - Proteomics – study of proteins in living organisms
    - Integration of genetic and environmental influences
    - All traits are defined by the action of proteins
    - Interacts directly with the transcriptome & metabolome
    - Researchable questions:
      - How many proteins exist in an organism?
      - What are their levels?
      - Where are they located and why?
      - How do they interact with each other and the environment?
      - How are they chemically modified naturally and manually?
      - What reactions do they catalyze?

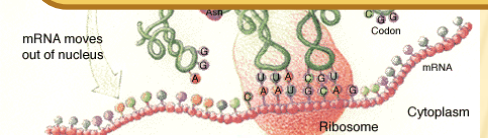
notype

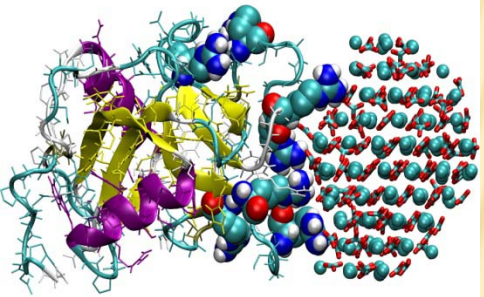
Transcriptome – “Integrates Genes and Proteins”

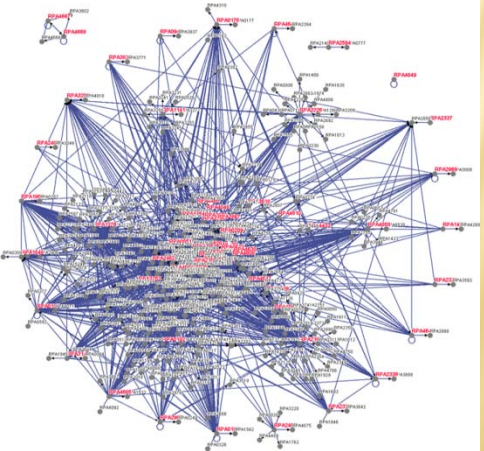
- ✓tRNA and mRNA use the ribosome to produce proteins
- ✓Precursor for the proteome – protein polymer
- ✓Subject to numerous internal mod
- ✓Subject to external environmen
- ✓RNA accounts for roughly 20%

Amino Acids

- ✓ 20 genetically coded Amino A
- ✓ Ribosomes build the proteins through translation







Protein

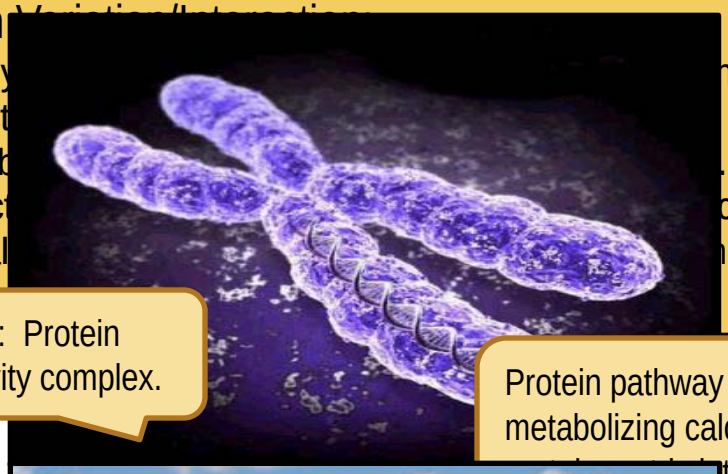
- ✓ Easily
- effect
- ✓ Numb
- ✓ Effect
- ✓ Local

netic

cription.

in the

Example: Protein interactivity complex.



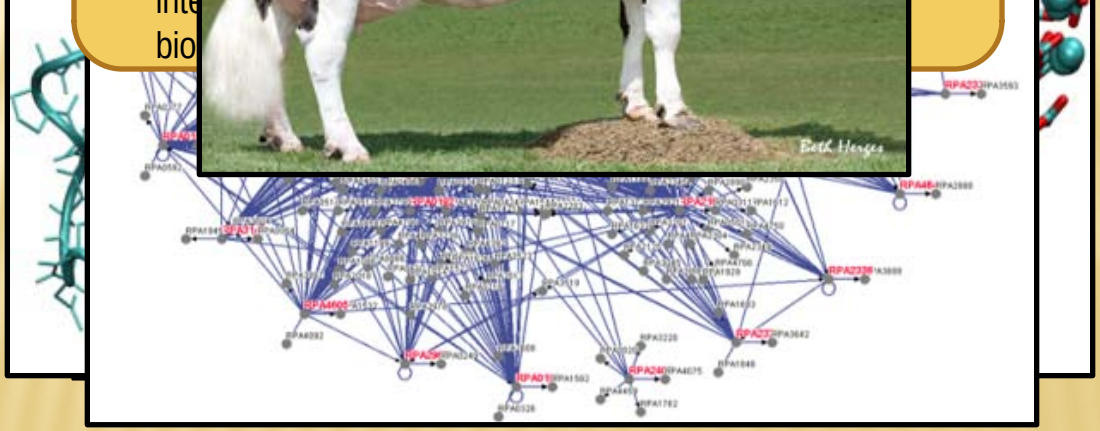
Protein pathway and cellular machinery metabolizing calcium carbonate via a

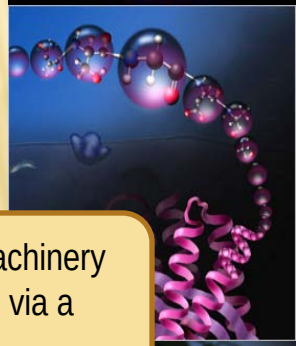
to eggshell.

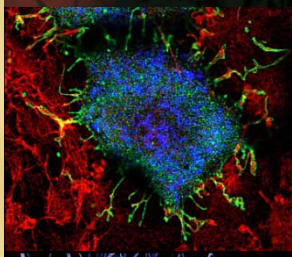
Prote

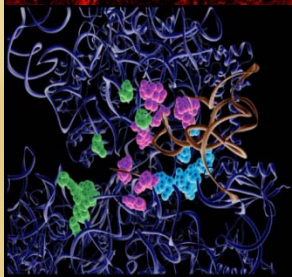
- ✓ Hig
- fun
- ✓ Lo
- inte
- bio

le.









MOVING FROM GENOTYPE TO PHENOTYPE

- Mastering the Environmental Component!
  - Functional Genomics and Animal Breeding
    - Synthesize genetic and proteomic information
    - Focus on component genetic systems for production traits – Strategy:
      - Dissect complex traits into component genetic pathways
        - Target genomic work on specific component pathways
        - Identify genes and resulting RNA products
        - Qualify/quantify resulting proteins and metabolic products
        - Associate with specific function in individual genetic pathways
      - Describe genetic and environmental contributions to parent trait
      - Address genetic and non-genetic implicating interactions
    - Prescribe selection and management protocols to optimize production traits in specific environments

MOVING FROM GENOTYPE TO PHENOTYPE

- Functional Genomics
  - Continued focus on GENOMICS
  - Integration of PROTEOMICS
  - CHALLENGE and OPPORTUNITY is the complexity
    - Larger science driven by systems biology
    - More interdisciplinary collaborative research
    - Extraordinary computing and bioinformatic needs
  - Potential impact is unlimited for biological systems
    - Realizing the “promise” of the genome
    - Personalized medicine, targeted selection, adaptation, etc
    - Maximize genetic progress for individual traits
    - Targeted genetic modifications/manipulations to introduce new traits or specific alleles for health, production and adaptability
      - Ability to “correct” negatively correlated traits
      - Opportunity to optimize genetic expression in specific environments

- Long road ahead!
- Enormous Opportunity!

- Thank you!
- Questions/Comments?