Food choice and nutritional well-being in livestock

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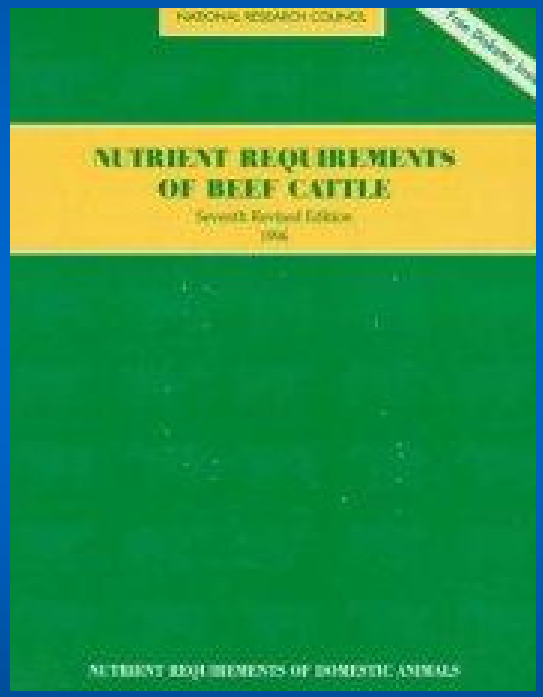
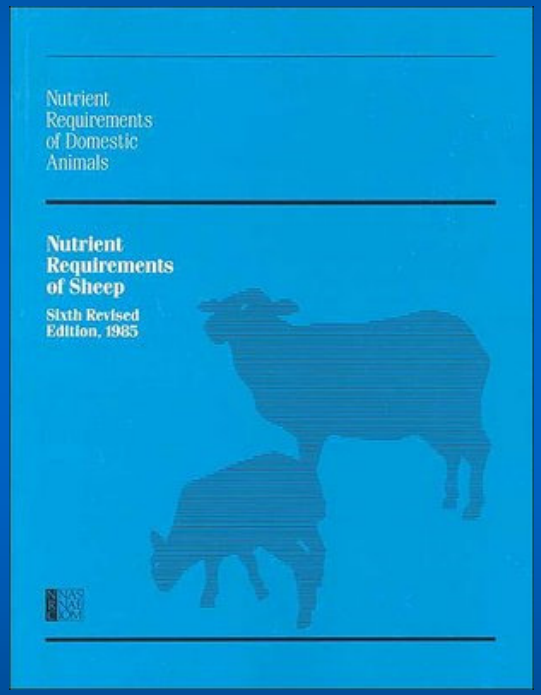
Animal Nutrition and Welfare

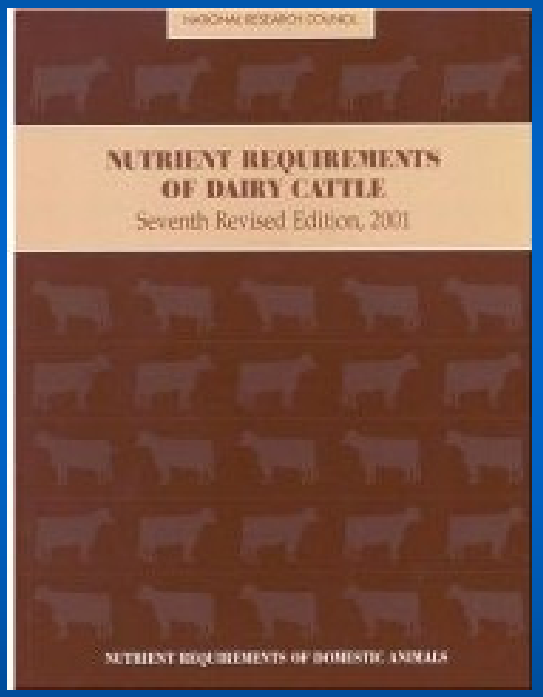
Nutrition is an important aspect of welfare since in most codes of recommendations for the welfare of animals, **adequate nutrition** is one of the primary requirements to be satisfied.

But…… What is adequate nutrition?

Tables of nutritional requirements?







✓If a nutritionist formulates a ration, or if ample food is provided to livestock, it is assumed that animal nutritional needs are met……

Nevertheless, in many cases the foods provided to animals are as wanting as the environments where animals are reared

This is because feeding systems typically do not consider:

1) The ability of livestock to build their own diets from a diverse array of foods.

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2) The fact that nutrients and flavors satiate animals and that satiety may be aversive.

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3) Fear to novel diets, and

This is because feeding systems typically do not consider:

1) The ability of livestock to build their own diets from a diverse array of foods.

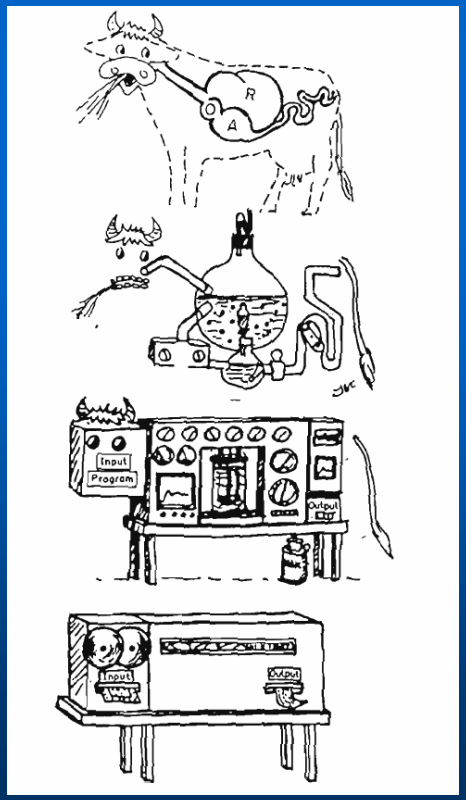
2) The fact that nutrients and flavors satiate animals and that satiety may be aversive.

3) Fear to novel diets, and

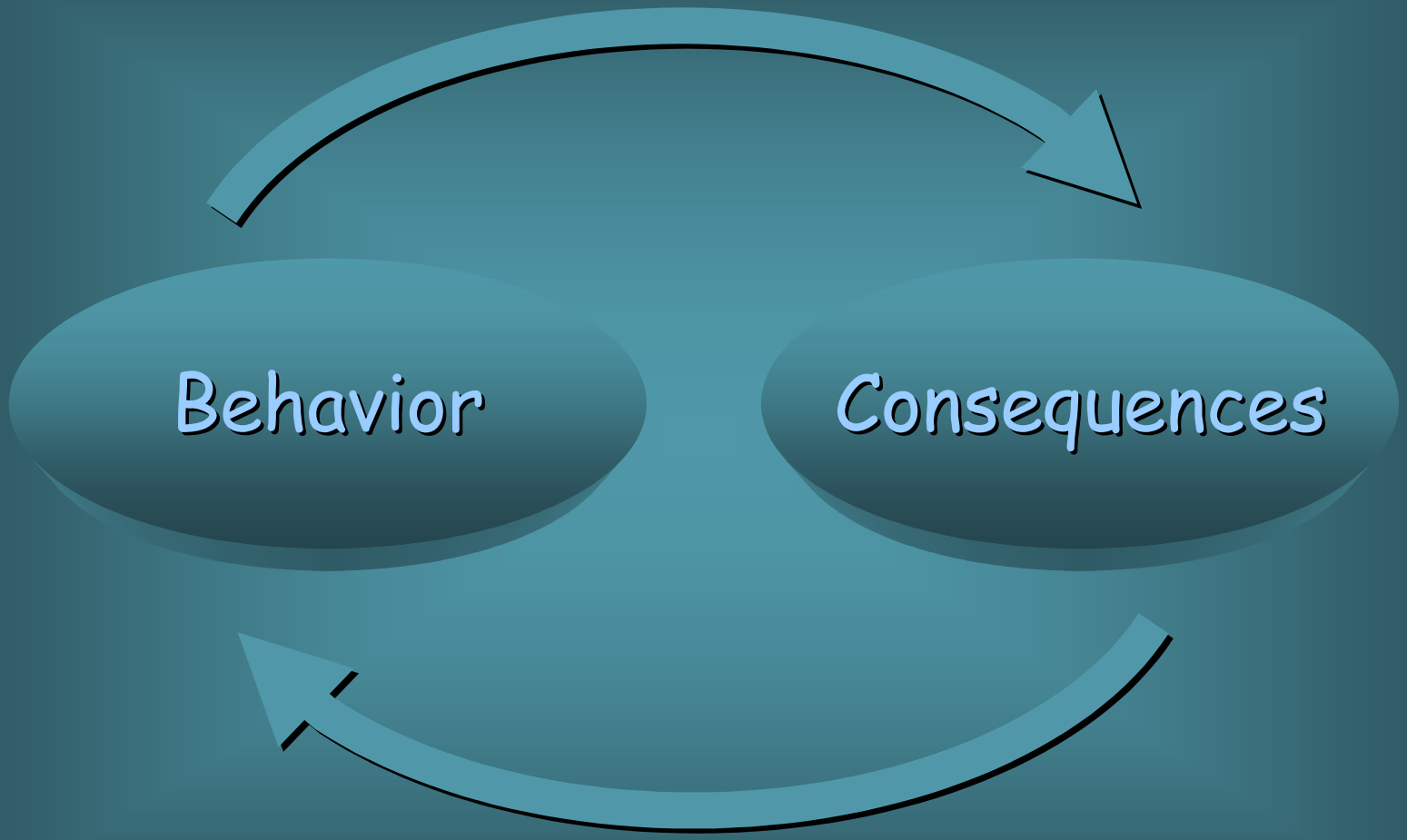
4) The inherent variability among individuals feeding on the same diet.

1- The ability of livestock to build their own diet – Behavioral Homeostasis

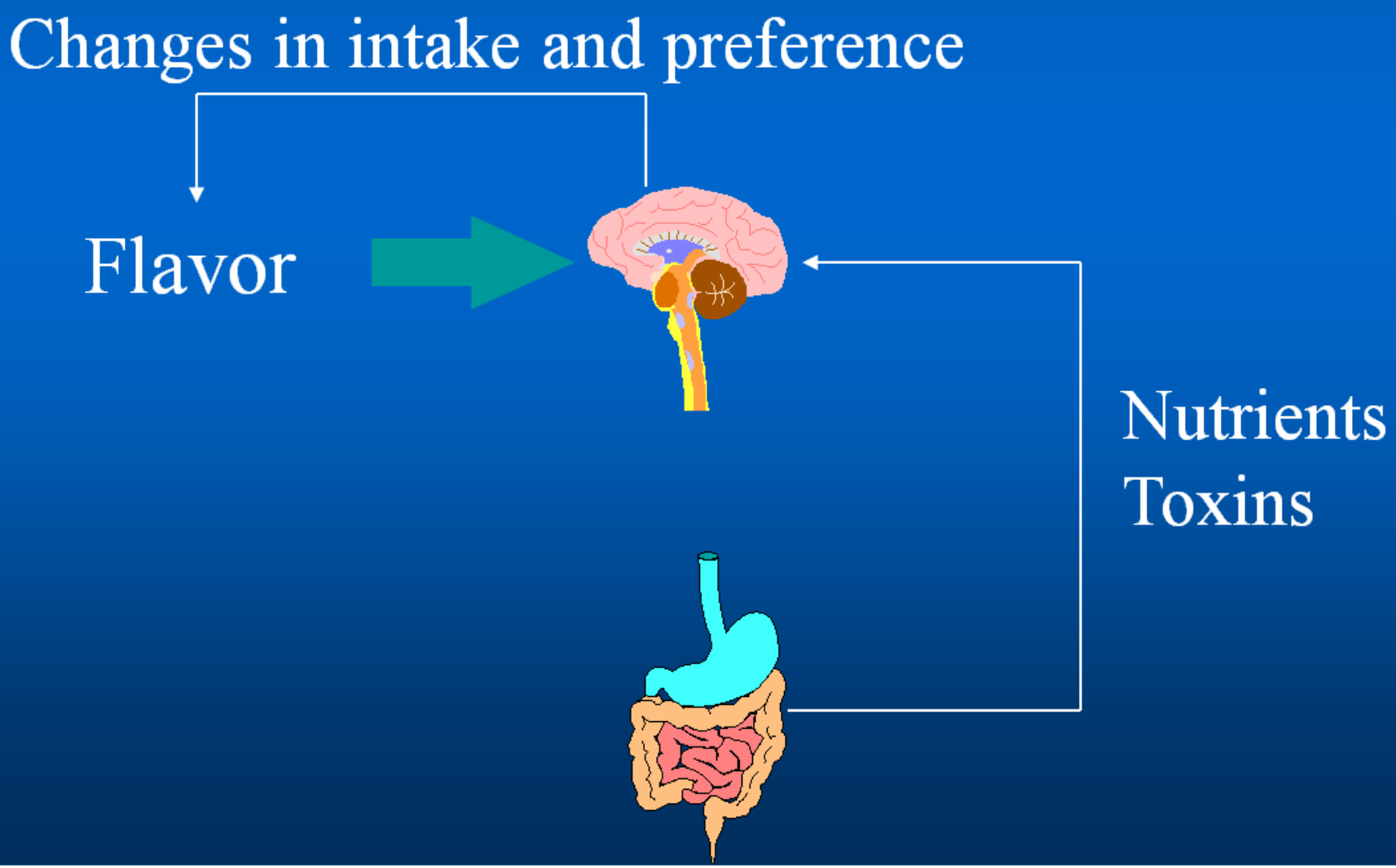
✓Since the domestication of herbivores 8,500 to 11,000 years ago, animals met their nutrient requirements and avoided toxicosis in complex and diverse feeding environments, long before the emergence of the field of ruminant nutrition .



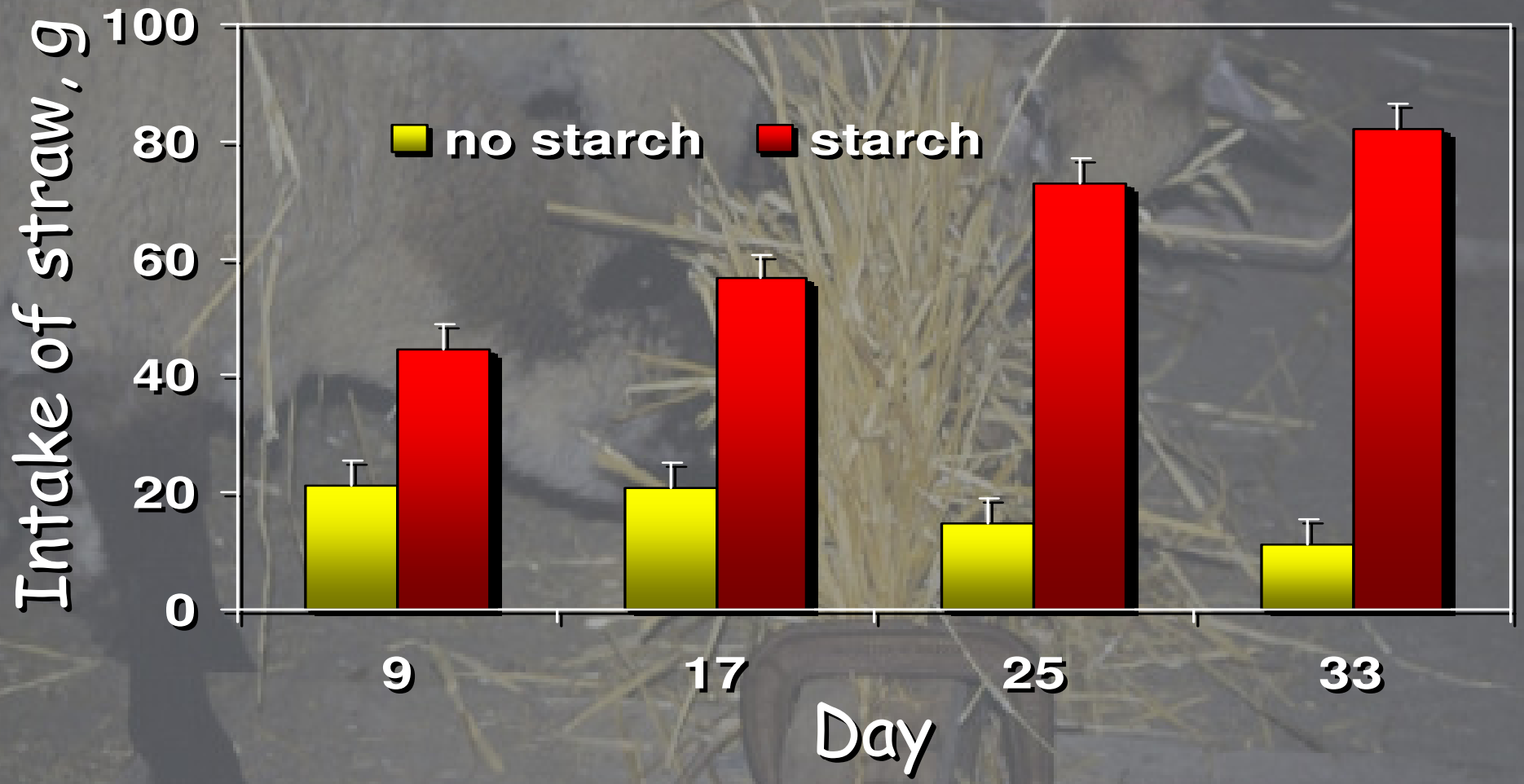
Czerkawski. 1985. An introduction to rumen studies.


Behavior
Consequences

Integration Flavor-Postingestive Feedback



Energy Increases Palatability

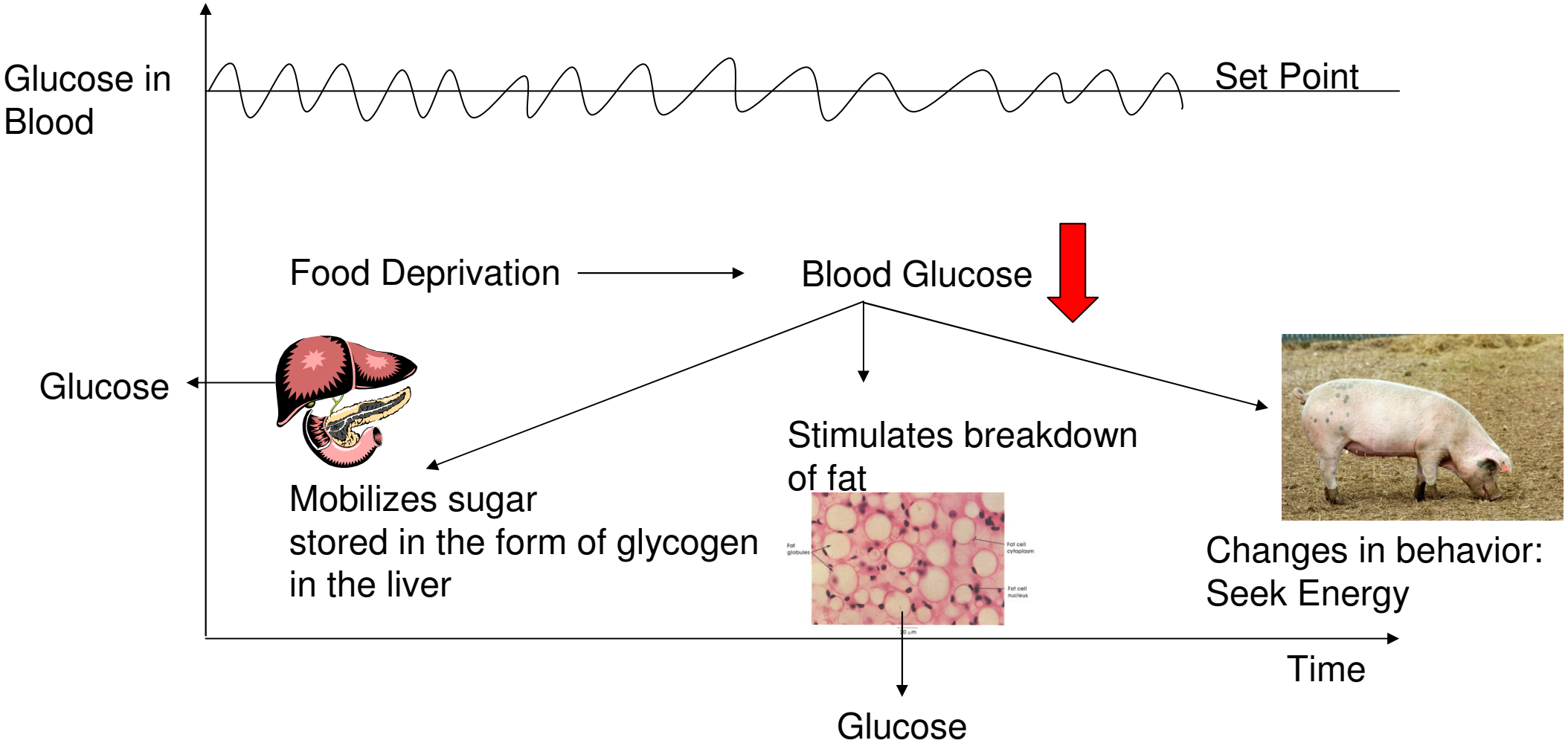


Villalba and Provenza, 1997

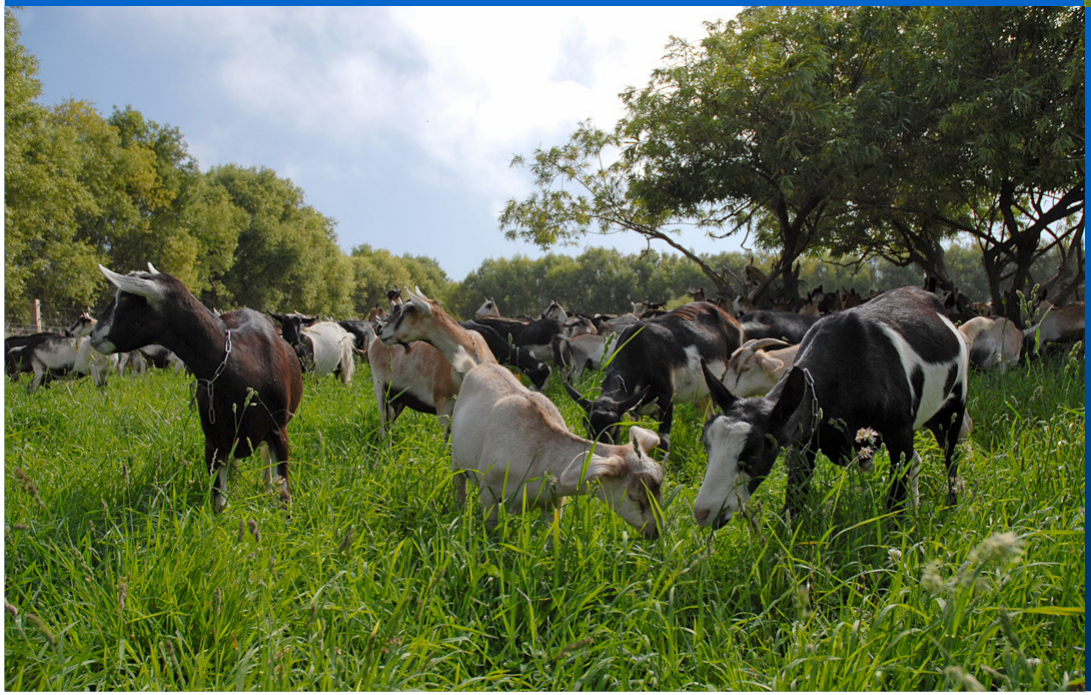
Behavioral Homeostasis

From a functional point of view, a behavior directed towards consumption of a food containing a needed nutrient is no different from the secretion of insulin in response to rising blood sugar levels:

Both responses have the common goal of restoring homeostasis.



✓The ability to select a balanced diet does not occur by chance alone. Livestock are active players in the field of nutrition……



…….they are not just entities passively responding to natural selection or formulated rations

✓Ruminants evolved in diverse feeding environments ingesting arrays of foods of contrasting nutritional and toxicological characteristics

✓Nevertheless, current intensive feeding systems are characterized by feeding animals monotonous rations and pastures in monocultures

Individuals can meet their needs for nutrients …..IF …they are offered a variety of foods (rations, pastures).

<u>Monotony. Single rations</u>: Animals cannot choose. In this context ***the only choice*** they have is to STOP eating (e.g., acidosis, excess NH3).

Five Freedoms

One of the most widely used conceptual frameworks to assess animal welfare in practice is that given by the United Kingdom Farm Animal Welfare Council (1993):

- Freedom from thirst, ***hunger and malnutrition***
- Freedom from discomfort
- Freedom from pain, injury and disease
- Freedom to express normal behaviour
- Freedom from fear and distress

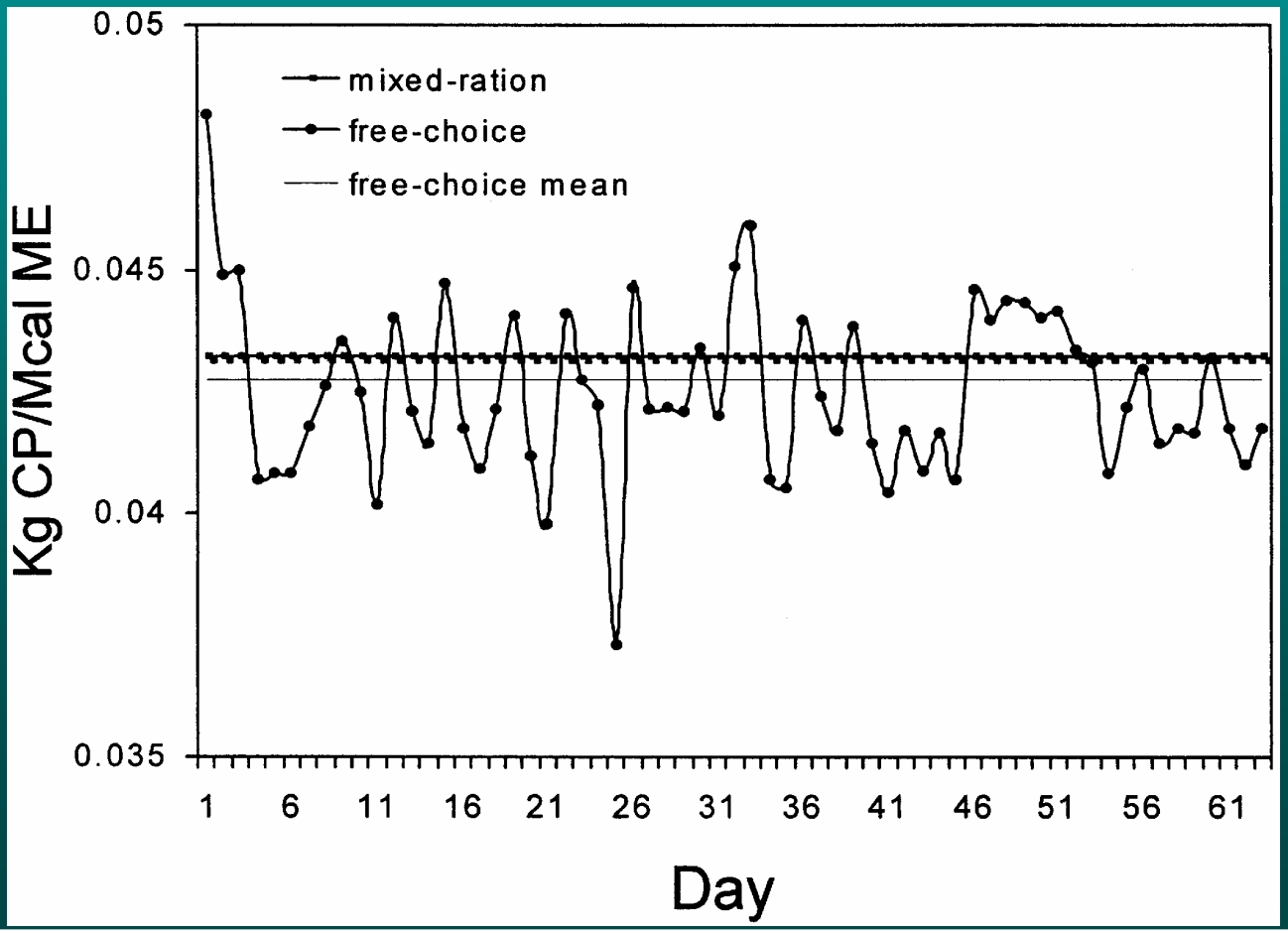
We propose a sixth Freedom:

- Freedom from thirst, ***hunger and malnutrition***
- Freedom from discomfort
- Freedom from pain, injury and disease
- Freedom to express normal behaviour
- Freedom from fear and distress
- Freedom to choose from a variety of feeds


Total Mixed Ration
versus
Free Choice
corn, barley, alfalfa, corn silage

Mixed Ration vs Choice

- Choice ate a little less than mixed
  - Same protein:energy ratio



- ✓Gained wt at the same rate
- ✓Similar gain/unit food consumed
- ✓Choice: Les cost to feed

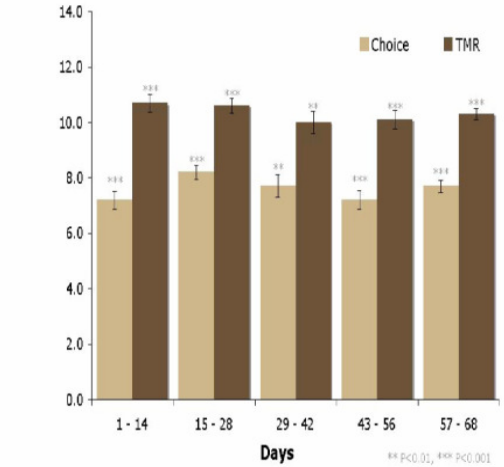
Atwood et al., 2001

Cattle in feedlots prefer more forage in their rations when given a choice

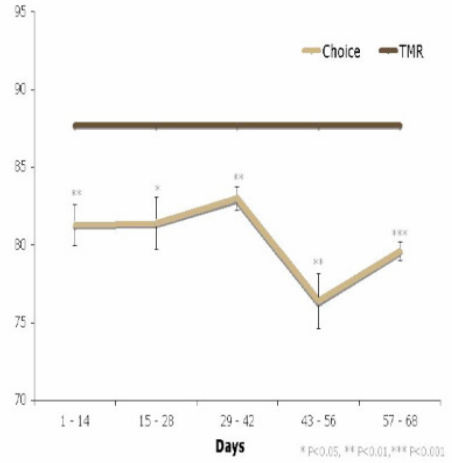
Rations 85-90% grain → acidosis

Choice:

Higher efficiencies (gain:feed ratios) 7% less barley and more silage



Heifers provided a choice had lower DMI and had a higher gain:feed ratio (0.17± 0.005 and 0.13±0.005 kg/kg, respectively; P<0.003).



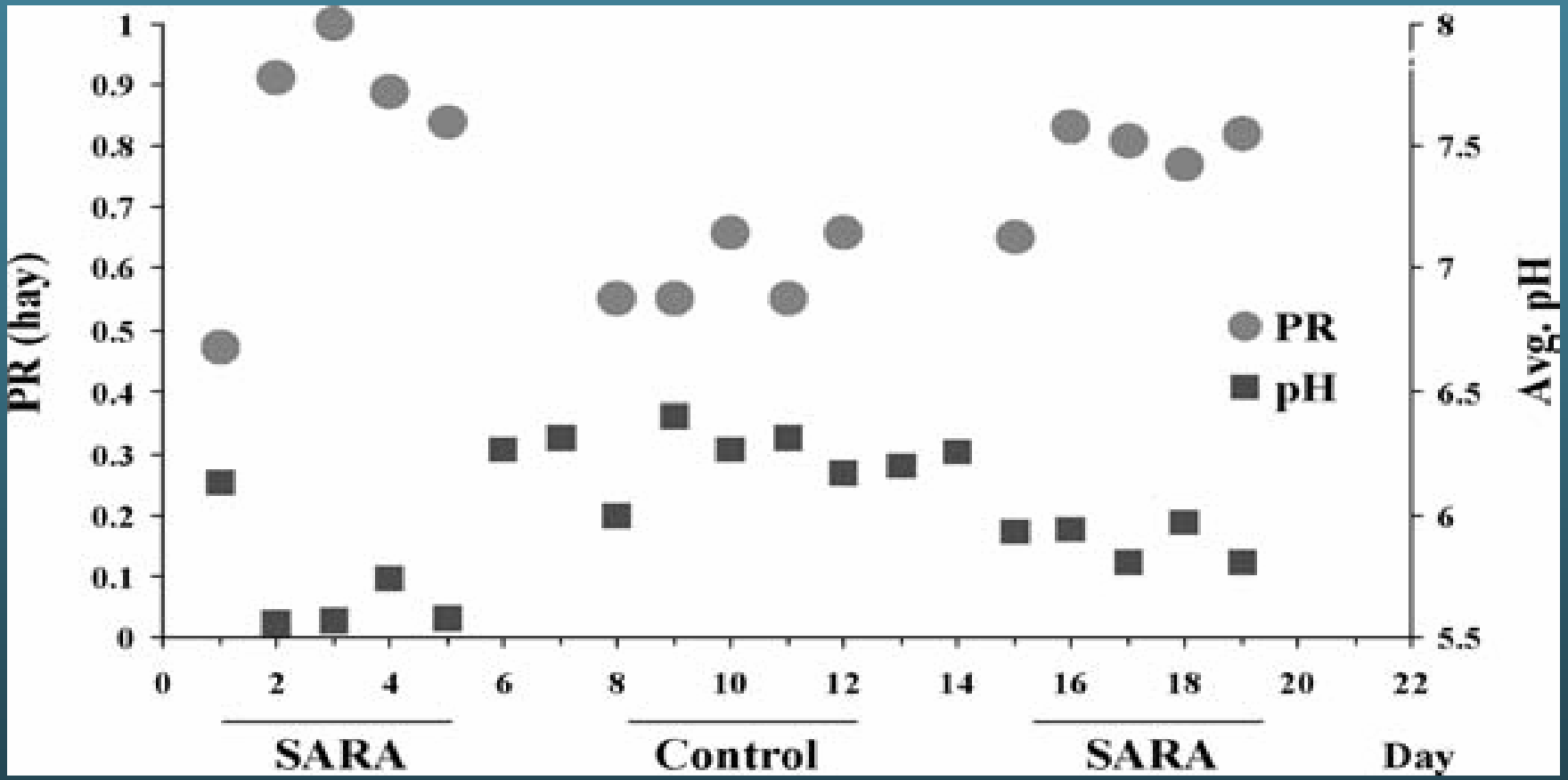
Choice heifers consumed 7% less barley than TMR heifers.

There were no differences in carcass characteristics between the two treatment groups.

Zobel et al., 2006

Sub-acute ruminal acidosis (SARA) and diet selection in dairy cows

Hay Preference (**PR**)



Keunen et al., 2002

Ruminal acidosis and diet selection in dairy cows

Dairy cows ***increase their selection*** of ***longer particles*** and decrease their selection of shorter particles when experiencing ruminal acidosis

DeVries et al., 2008

Kent Fullerton at the Iron Mountain Bison Ranch
http://extension.usu.edu/behave/

Bison Feedlots
-Wyoming
-Montana

TMR vs. CHOICE:
CHOICE increased gains, reduced acidosis and scours, reduced veterinary costs , reduced stress……

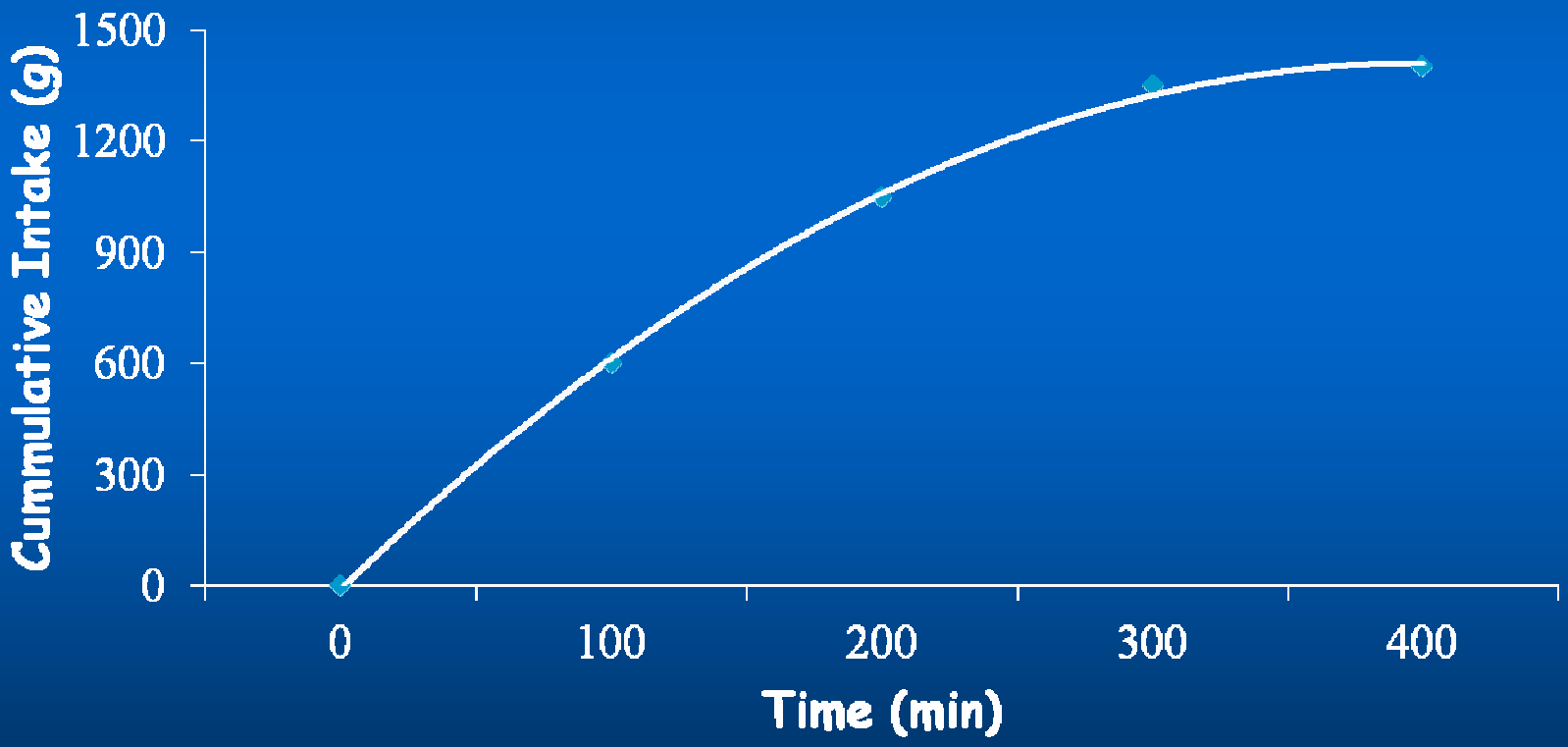
2- Nutrients and flavors satiate animals - The satiety hypothesis

Eating the same food day after day……?

Satiety Hypothesis

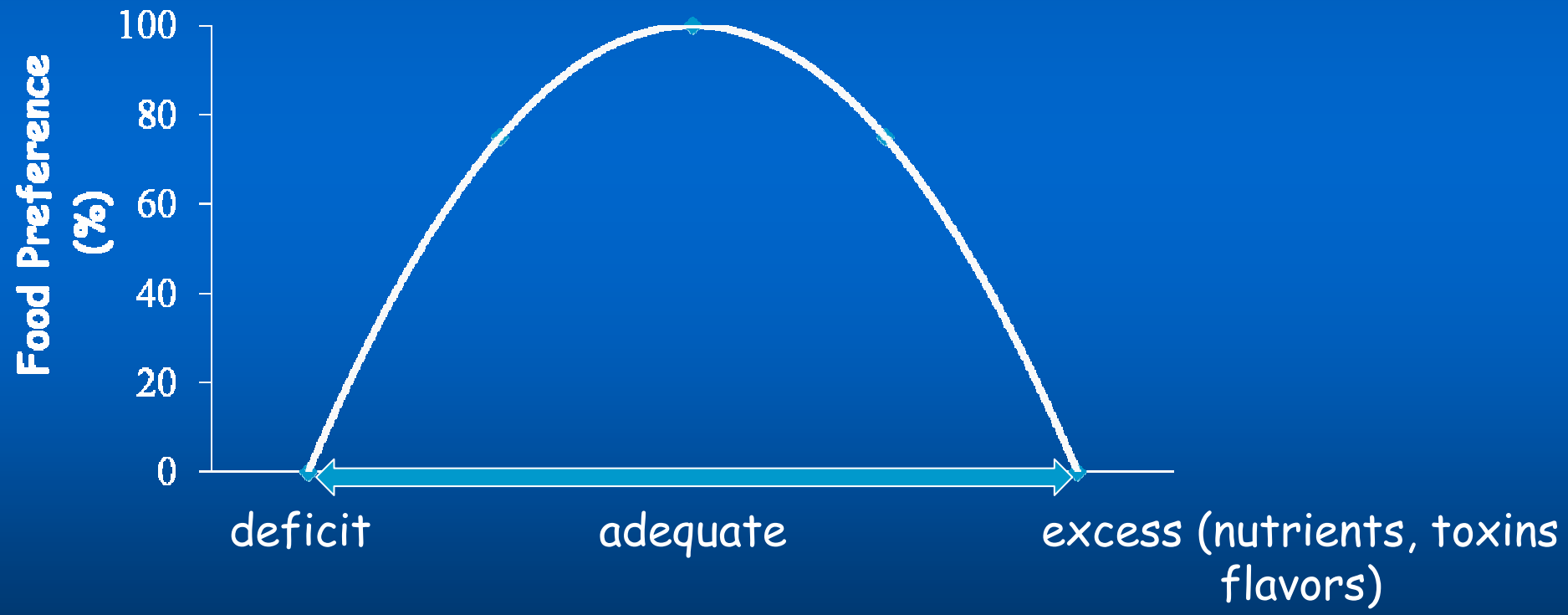
Satiety-Malaise Continuum

- *Flavors*, *nutrients*, and *toxins* cause satiety



Satiety-Malaise Continuum

- Satiety is mildly to strongly aversive



Satiety-Malaise Continuum

- Food aversions cause varied diets
- Food aversions can be stressful

If satiety is aversive……

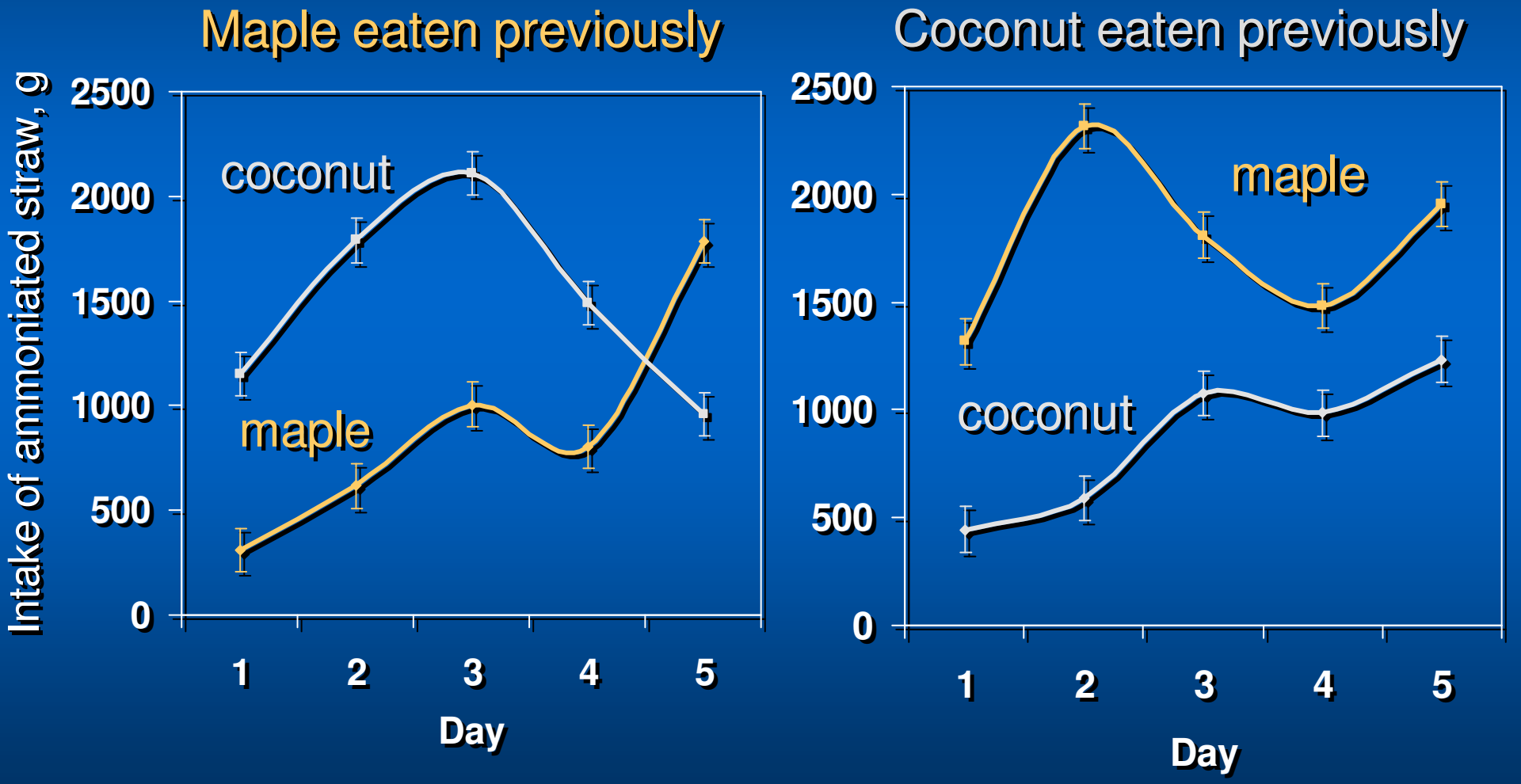
Which are the implications for animal welfare?

Flavor-Specific Satiety

Neural Basis of Sensory-Specific Satiety

Neurons for taste, smell, and sight stop responding to the taste, odor, and sight of a food on which an animal has been fed to satiation, yet they continue to respond to other foods.

Flavor-Specific Satiety



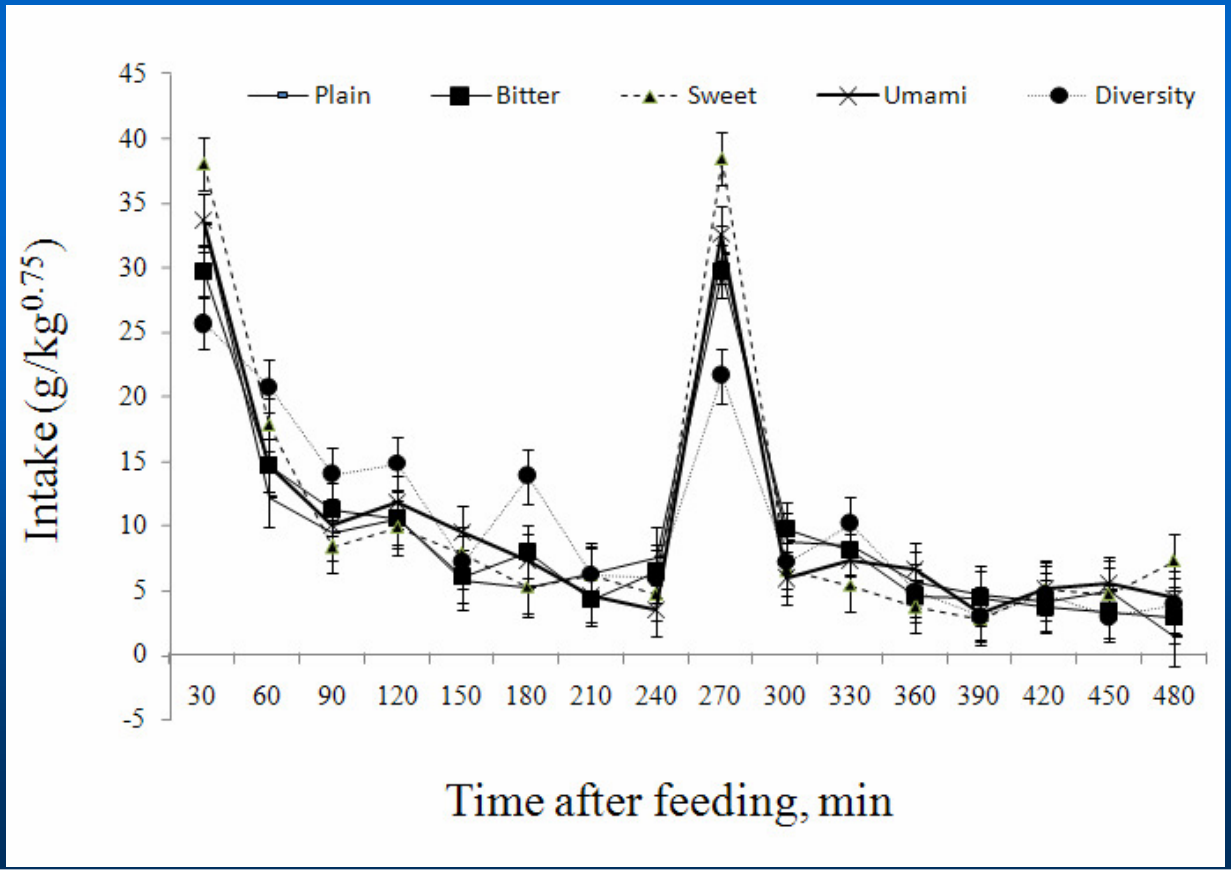
Atwood et al., 2001

Choice of flavors in the same ration (Flavor Diversity)

✓ Lambs offered a choice of flavors ate more and tended to grow faster than lambs offered flavor monotony.

✓ Flavor diversity induces a more even spread of feed intake throughout the day.

✓ This effect could reduce rumen pH fluctuations, potentially enhancing the synchrony of nutrient supply to the host.

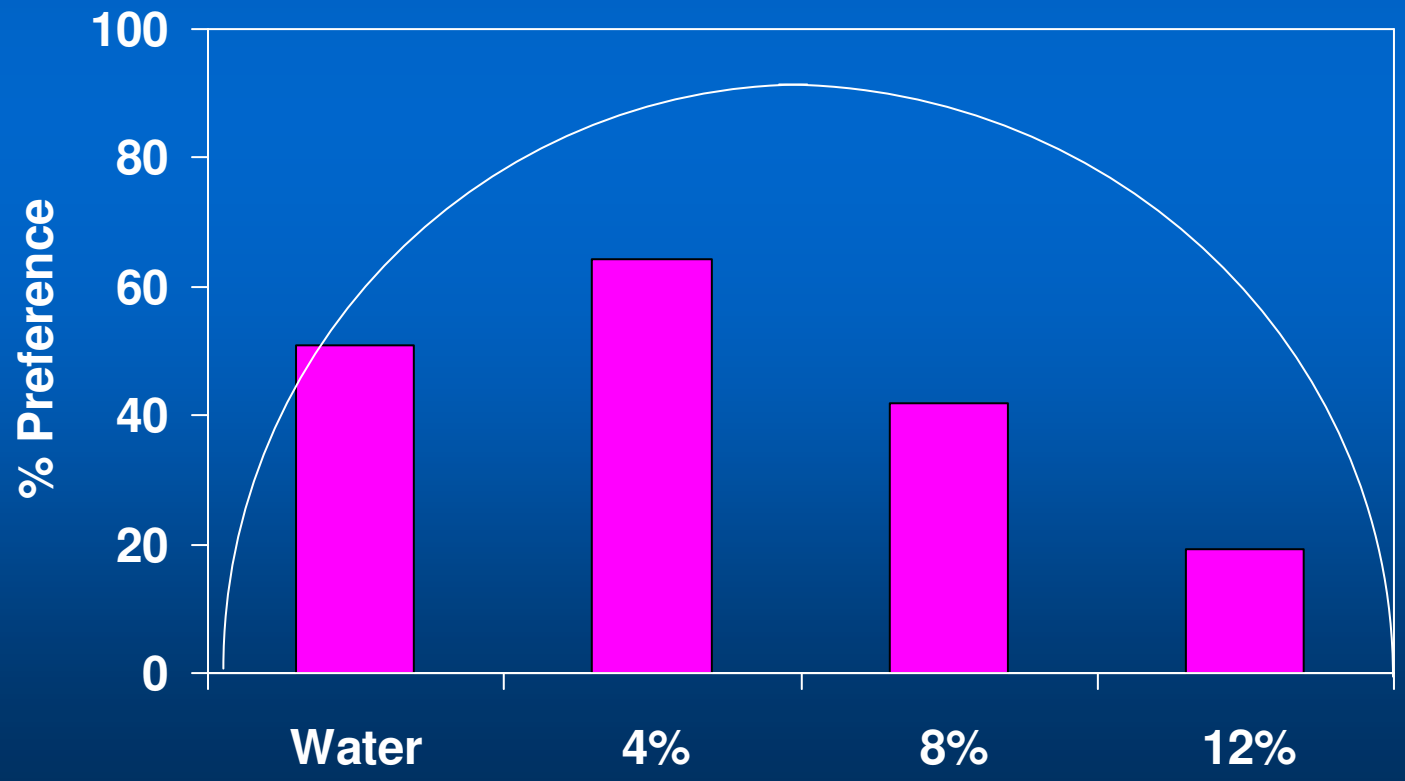


Villalba et al., 2011

Nutrient-Specific Satiety

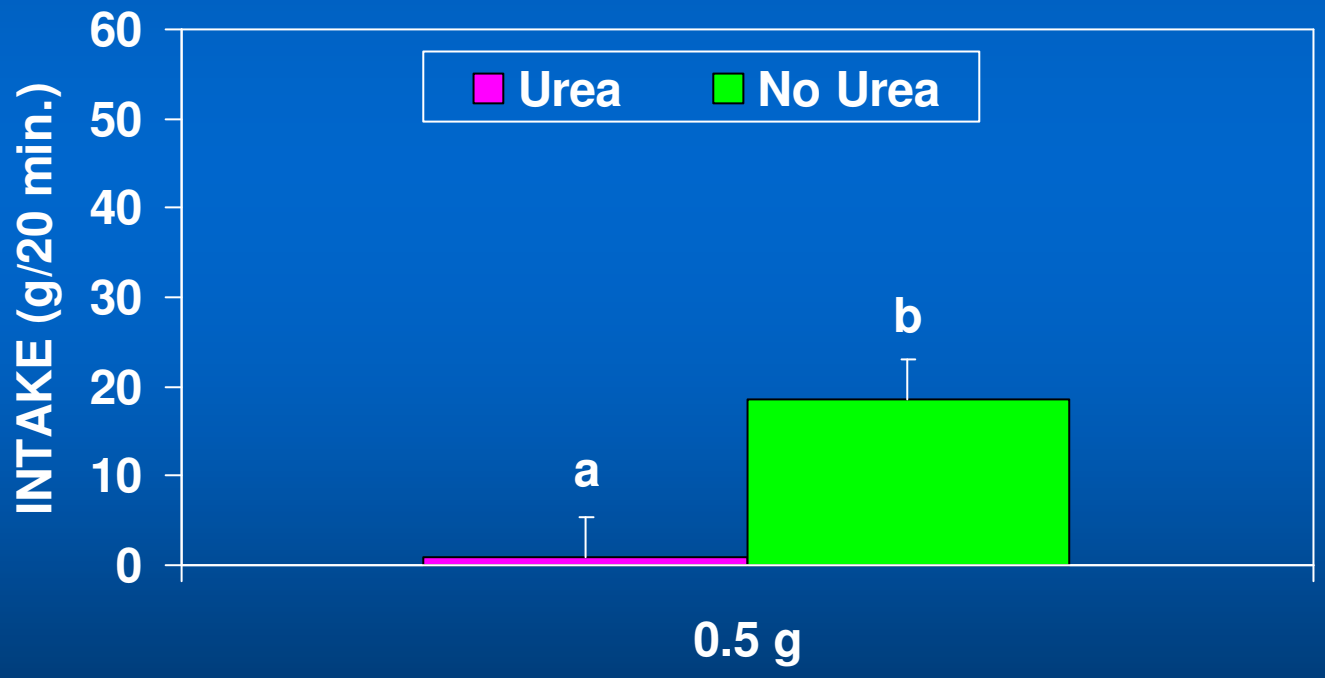
Dose-dependent Continuum

Preference for flavors associated with intraruminal infusions of Volatile Fatty Acids

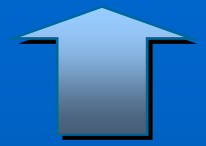
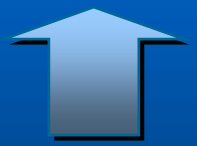


Villalba and Provenza, 1997

Preference for Flavors associated with intraruminal infusions of urea



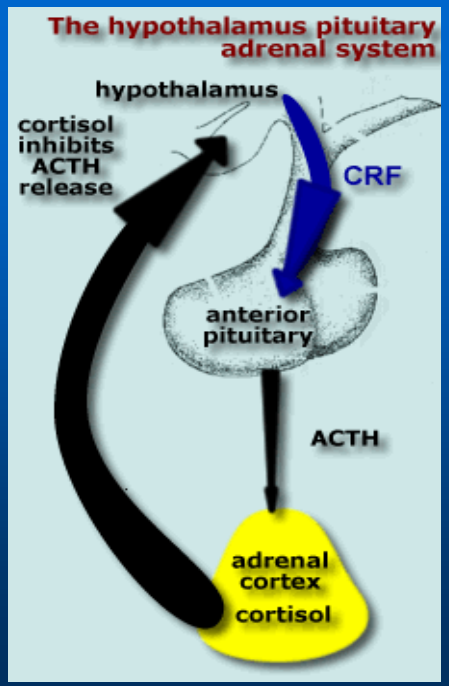
Balancing energy and protein:

	Preference	
Meal	Energy	Protein
Energy		
Protein		

What's fed in the barn...

...influences what cows eat on pasture

Stress due to monotony

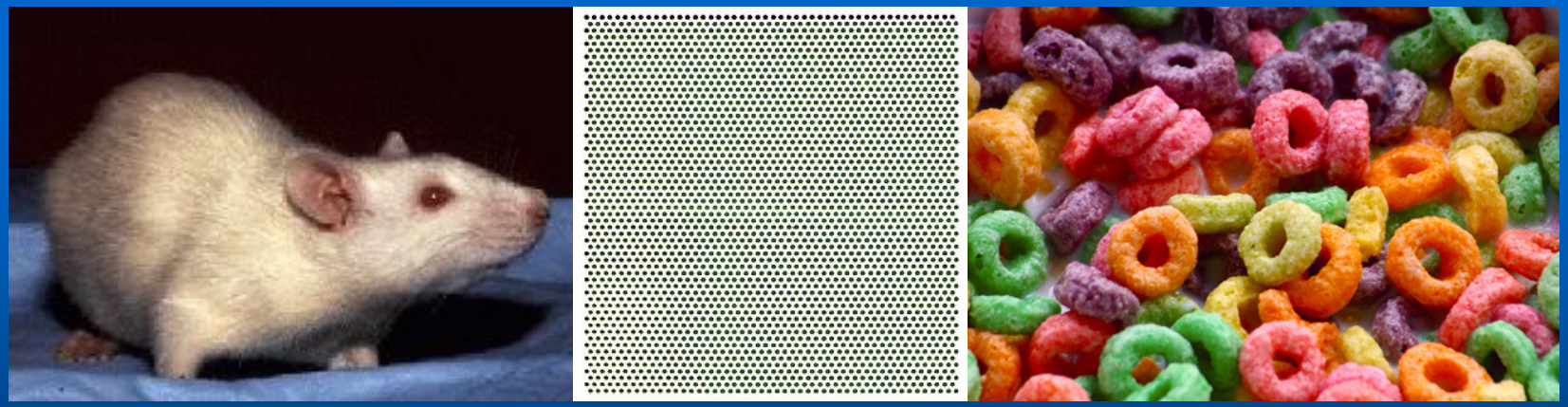


Activation of the hypothalamic-pituitary-adrenal (HPA) axis:

↑ Cortisol in plasma, saliva, feces.

Is monotony stressful?

Rats exposed to attractive and but inaccessible food cues (Froot Loops) and fed a monotonous ration manifest higher levels of stress than rats deprived from such exposure as measured by concentration of corticosterone in blood



↑Stress

Polivy et al., 2008

Is monotony stressful?

We determined whether early experiences by sheep to monotonous or diverse diets influence plasmatic profiles of cortisol, a hormone involved in stress responses by mammals

Diversity

A **choice** of all possible 4-way combinations of 2 feeds with low and 2 feeds with high protein/energy ratios from an array of 6 feeds:

Low protein/energy ratio:
1.beet pulp,
2.oat grain,
3. milo:grape pomace [60:40]

High protein/energy ratio:
1.Soybean meal
2.Alfalfa
3.Corn gluten meal

Diversity + Phytochemicals

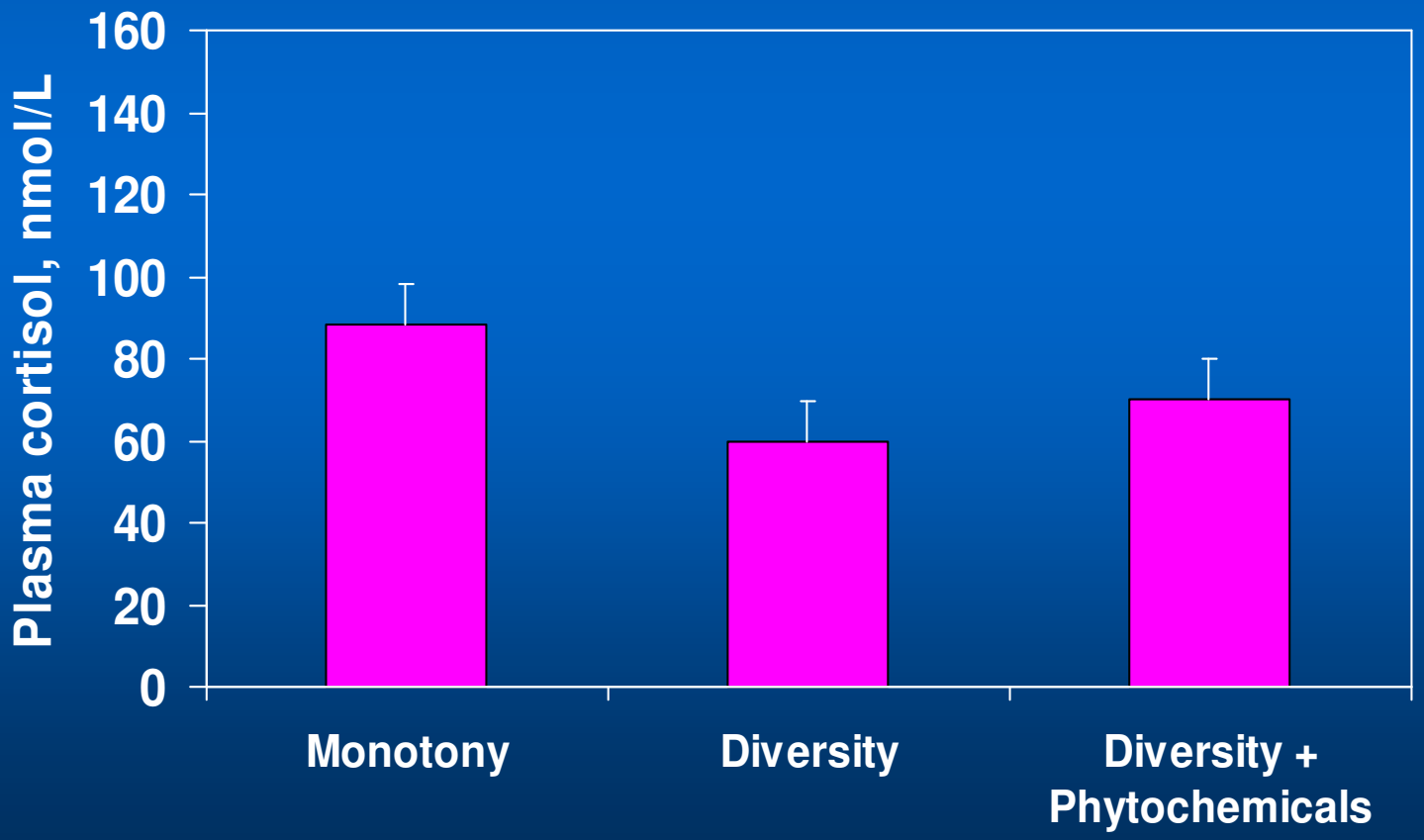
The same choice described for Diversity but two phytochemicals, oxalic acid (1.5%) and quebracho tannins (10%) were randomly added to foods high in energy or to foods high in protein

Monotony

A **monotonous** balanced ration containing all 6 foods fed to the other groups.

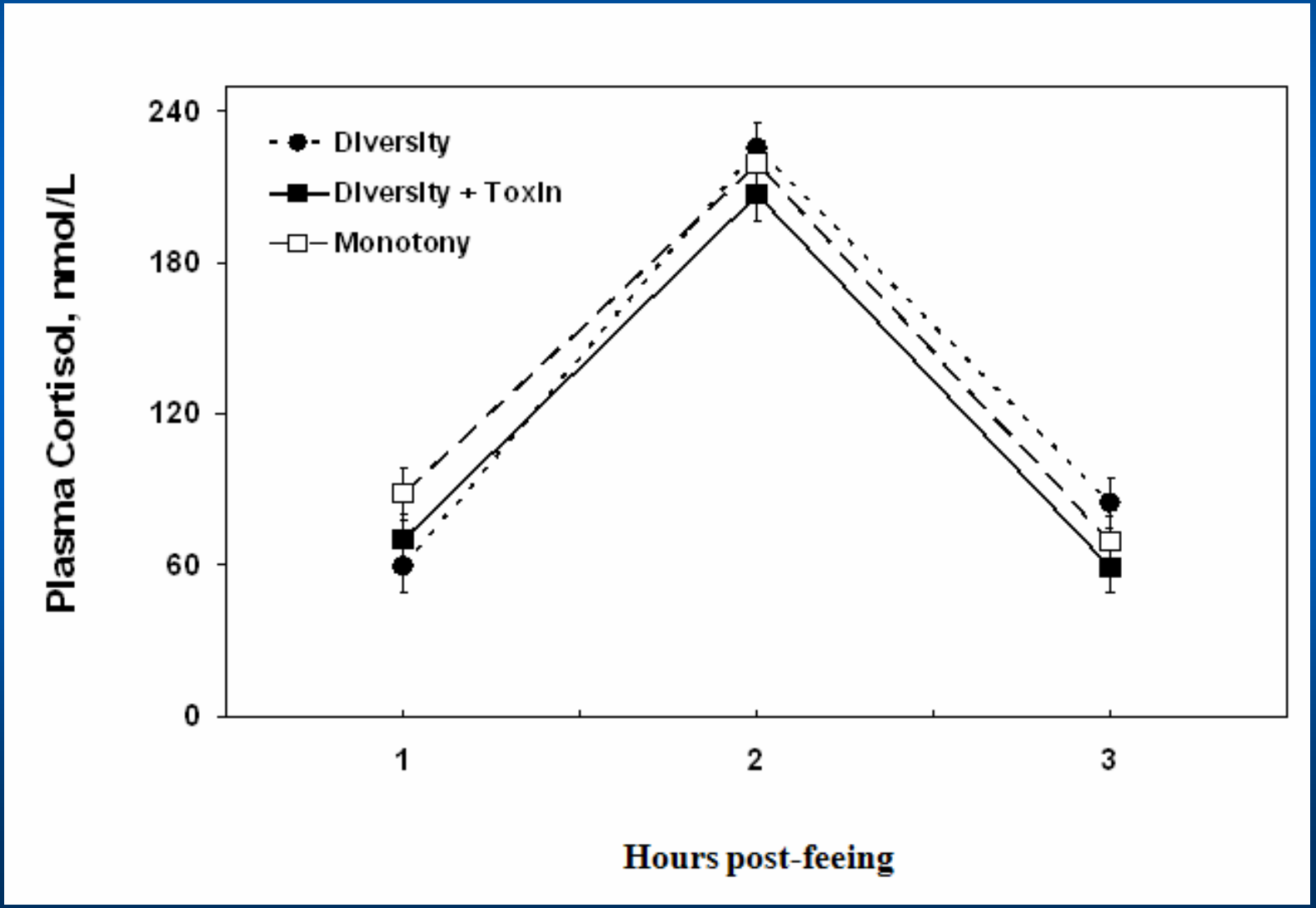
Villalba et al., 2011

Lambs in Monotony showed greater concentrations of plasma cortisol 1 h after food presentation than lambs in the Diversity or Diversity+Phytochemical treatments

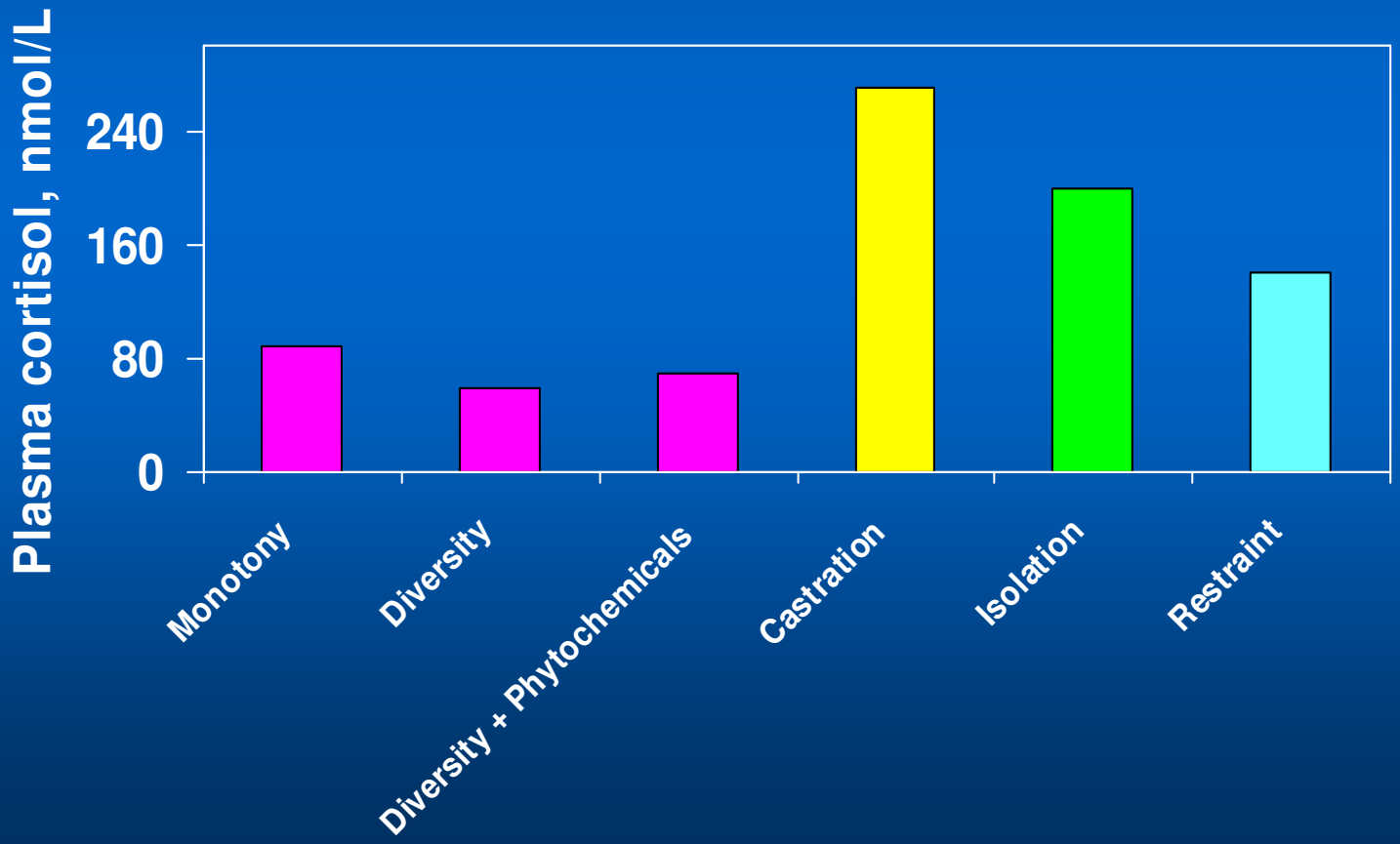


Villalba et al., 2011

However, no differences among treatments were detected after an ACTH challenge

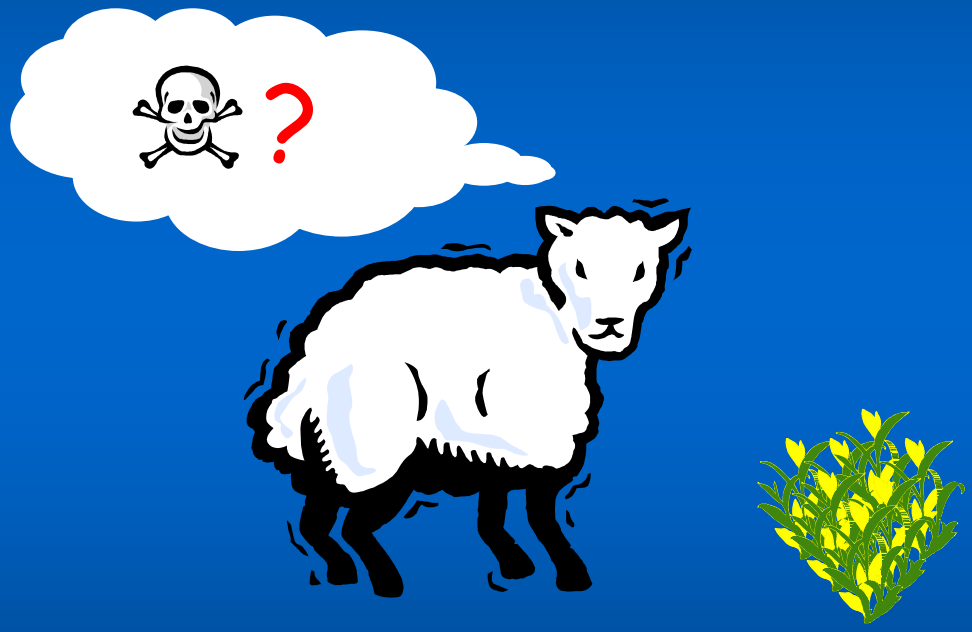


Responses to other stressful situations seem to yield greater concentrations of cortisol in lambs



Villalba et al., 2011

3- Fear to novel diets



Food neophobia = A behavioral response elicited by animals to avoid over-ingesting toxins or nutrients from foods with unknown postingestive effects.

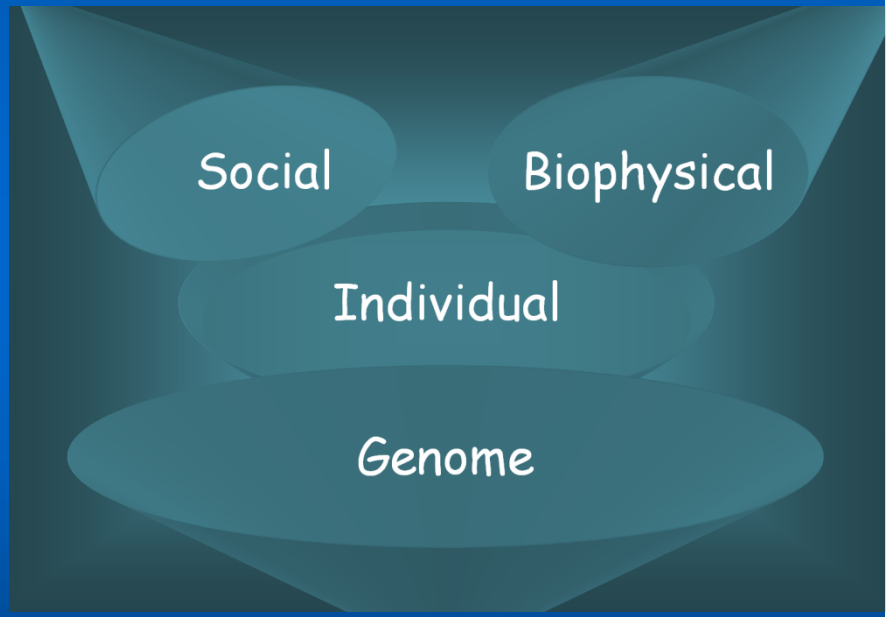
Food neophobia

Exposure to novelty is one of the most potent experimental conditions to cause negative emotions of fear and anxiety (Boissy, 1998).

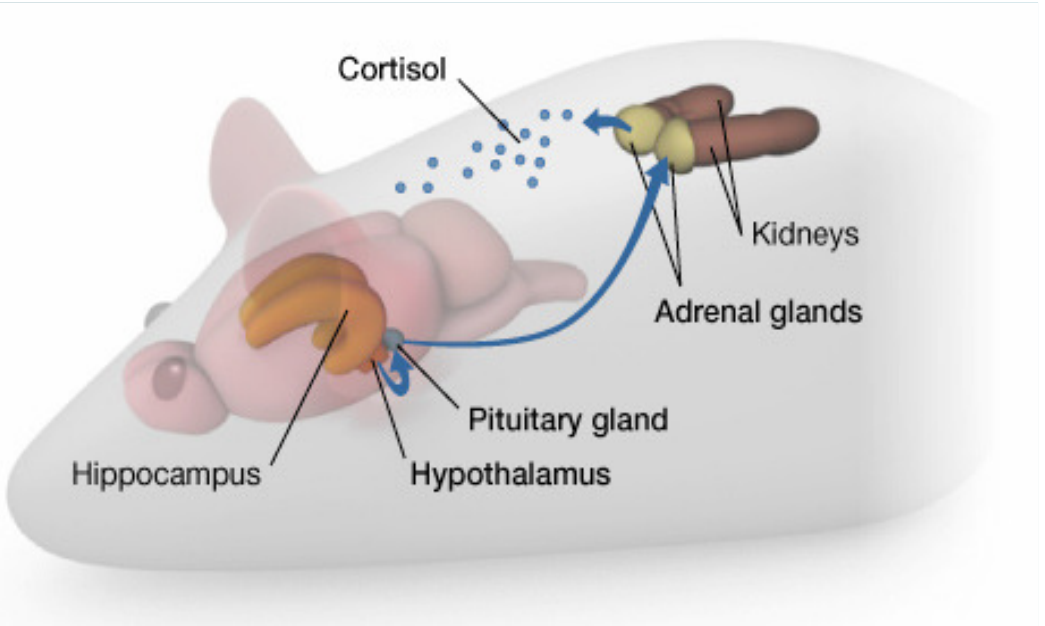
This is probably why animals typically sample novel foods cautiously (Chapple and Lynch, 1986).

Food neophobia and experience with food

Past experiences *in utero* and early in life have have life-long influences on diet, health and disease in humans and herbivores by causing ***neurological, morphological, and physiological changes*** that influence foraging behavior.



By interacting with the genome during growth and development, social and biophysical environments influence gene expression and behavioral responses



Variations in licking and grooming by female rats can alter the function of the hypothalamic-pituitary-adrenal (HPA) axis and stress response in their offspring, by directly altering gene expression (Weaver et al., 2004).

Early Experience to Food Diversity and Fear

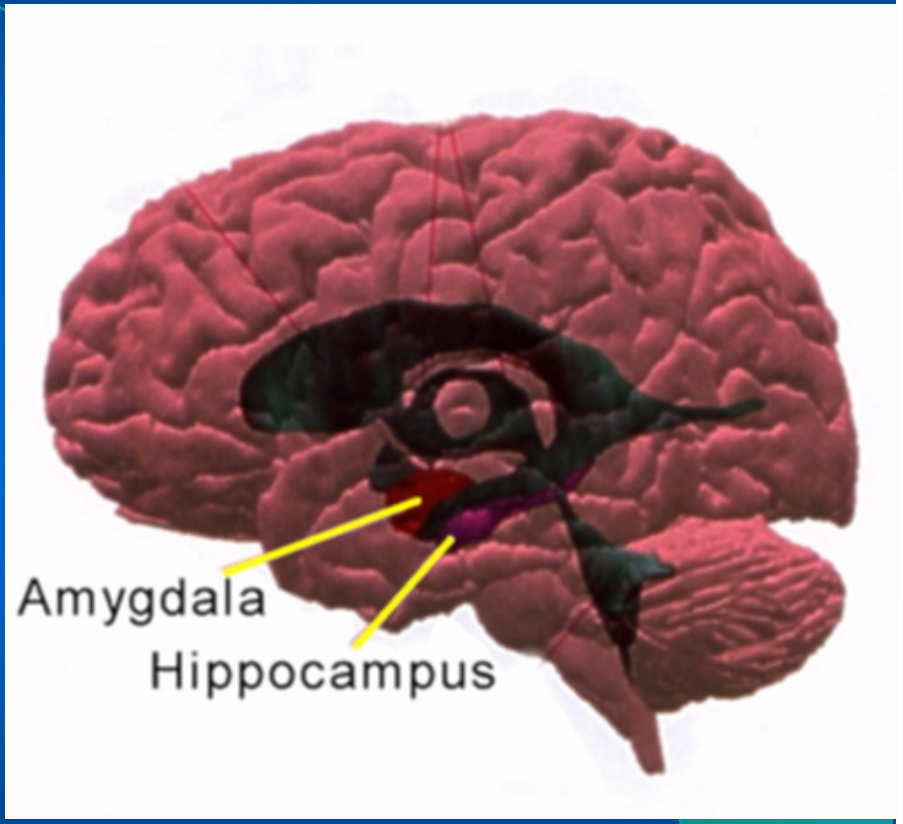
Fear responses to new foods and locations may be influenced by an animal's previous experiences with foods.

It is likely that early experiences to a diverse array of foods may attenuate fear responses towards novelty in general, which will be reflected in a higher acceptance of new foods and environments.

Villalba et al., 2011

Fear, Diet Selection, and Stress

The neural substrate responsible for the fear response is involved in diet selection as neuronal networks in the amygdala and the hippocampus are involved in both fear and diet selection (Bechara et al., 1995).



Early Experience to Food Diversity and Fear

Is there a link between early experience to food diversity and general fearfulness and response to separation – as measured by the open field test (OFT) and stress induced hyperthermia (SIH)?

Open field test

Villalba et al., 2011

Open Field Tests

Open field tests generally consist of exposing a single animal to an empty arena surrounded by walls and recording its behavior over a certain period of time (10-15 min). This procedure may induce acute stress, reflected in hyperthermia (SIH) and activation of the hypothalamic-pituitary axis with the result of an increased secretion of cortisol from the adrenal gland.

Villalba et al., 2011

The same 3 groups of lambs exposed early in life to: 1) Food Diersity, 2) Diversity + Phytochemicals, and 3) Monotony were tested later in life in an open field test:

Experience Early in Life

Diversity

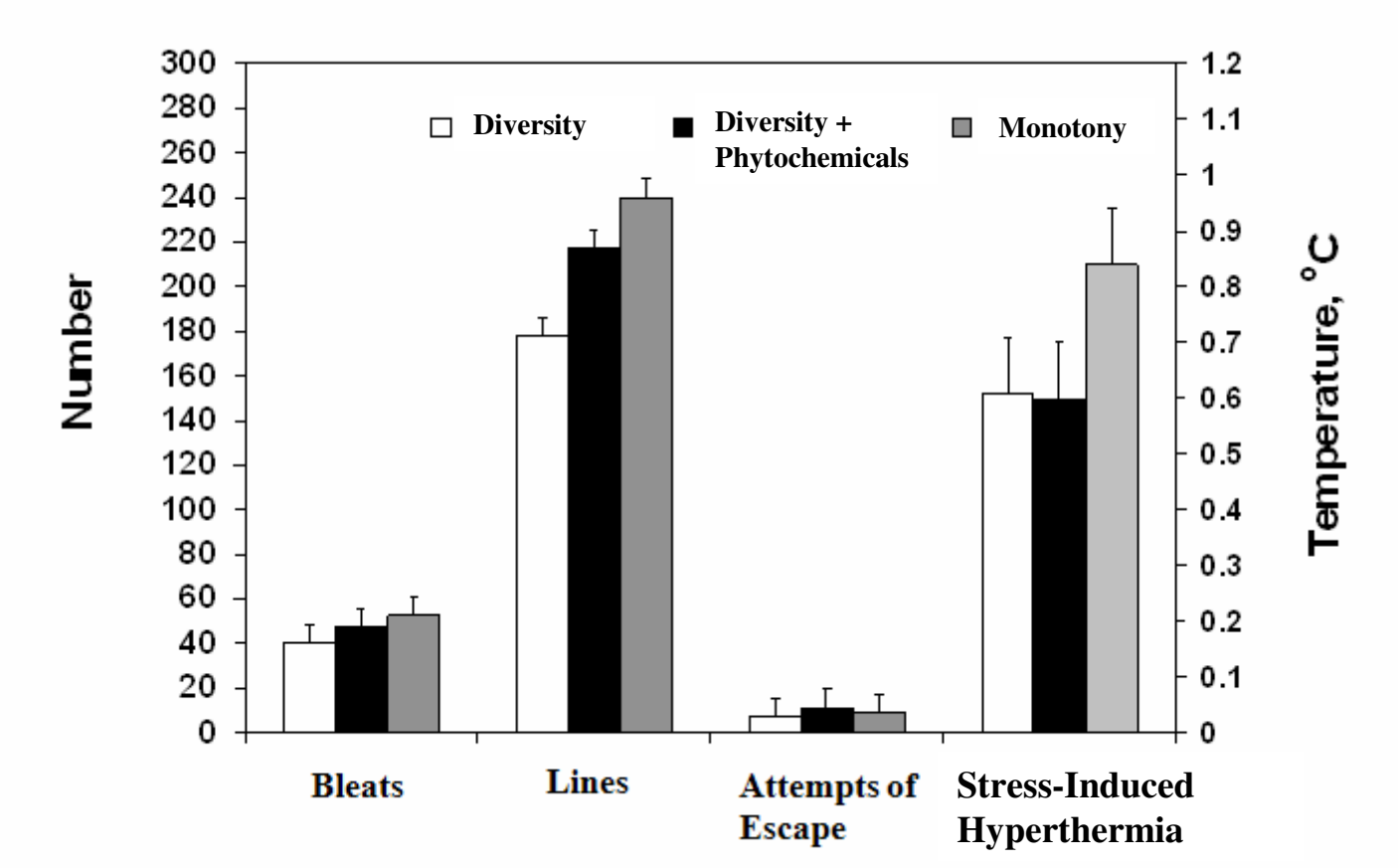
Diversity + Phytochemicals

Monotony

Open Field Test

Villalba et al., 2011

Lambs exposed early in life to food diversity showed lower increase in rectal temperature (stress-induced hyperthermia) than lambs exposed early in life to food monotony.

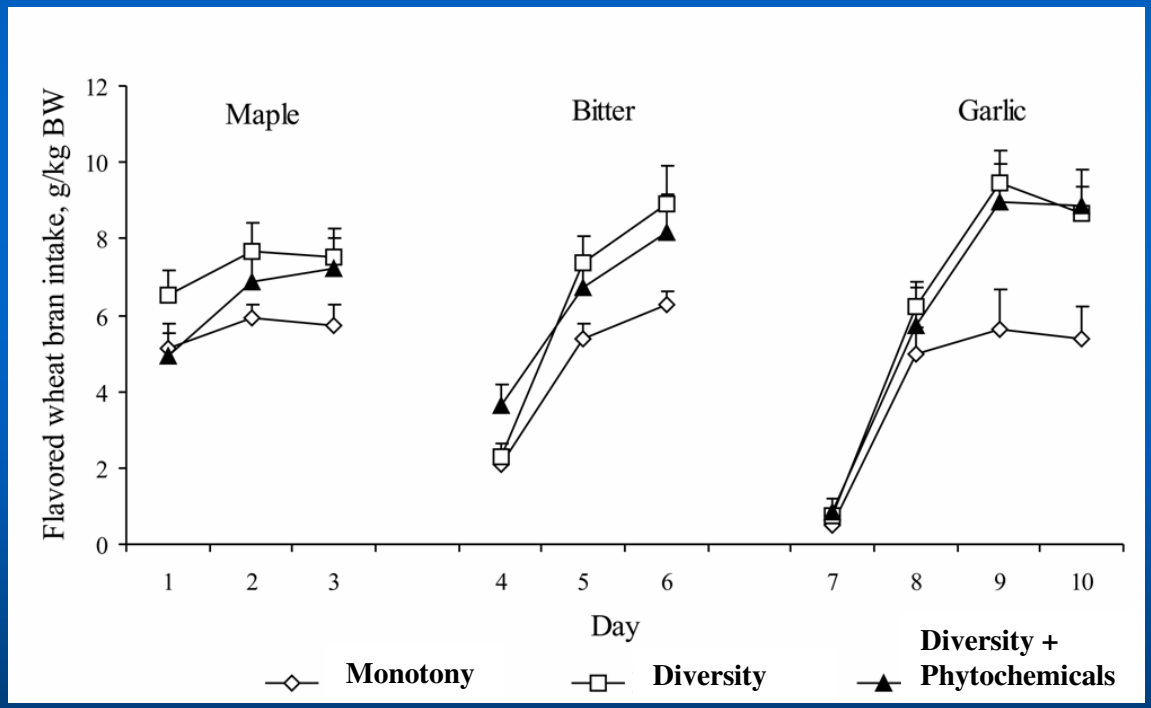


Villalba et al., 2011

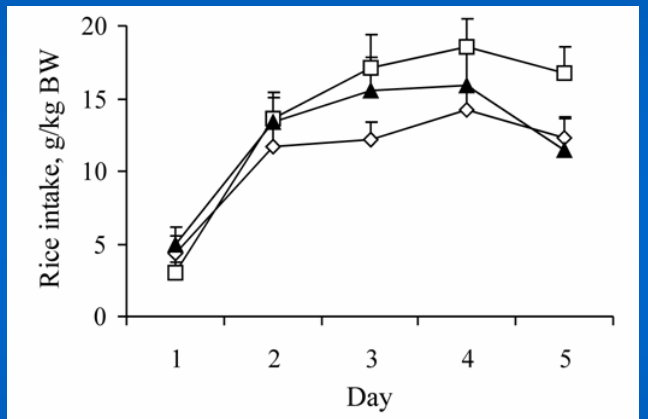
Can we make animals more/less neophobic and more/less tolerant to monotony by experiences in utero and early in life?

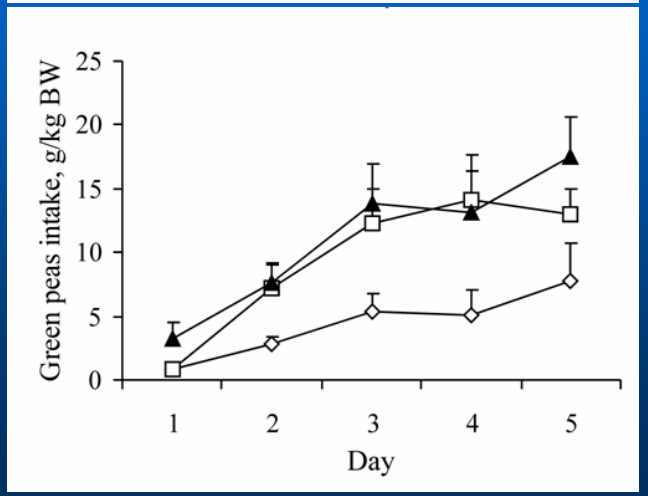
✓Compared with lambs exposed early in life to a monotonous diet, lambs exposed early in life to diverse feeds showed a subsequent higher intake of a familiar feed **containing novel flavors** and novel feeds.

Novel Flavors



Novel Feeds

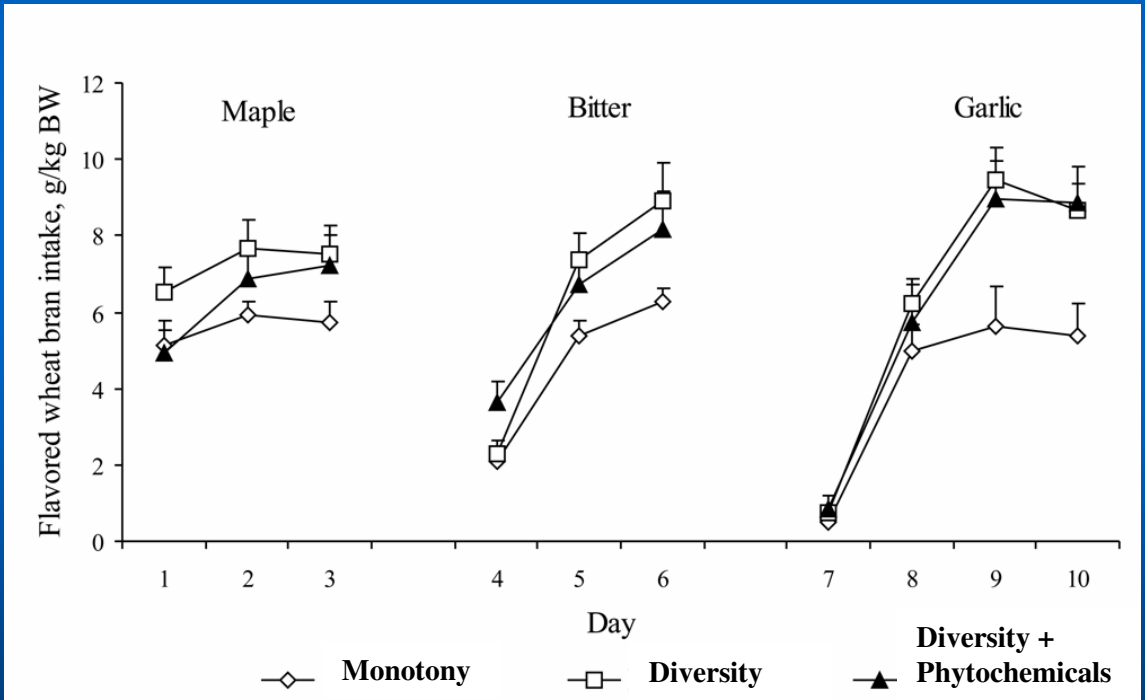




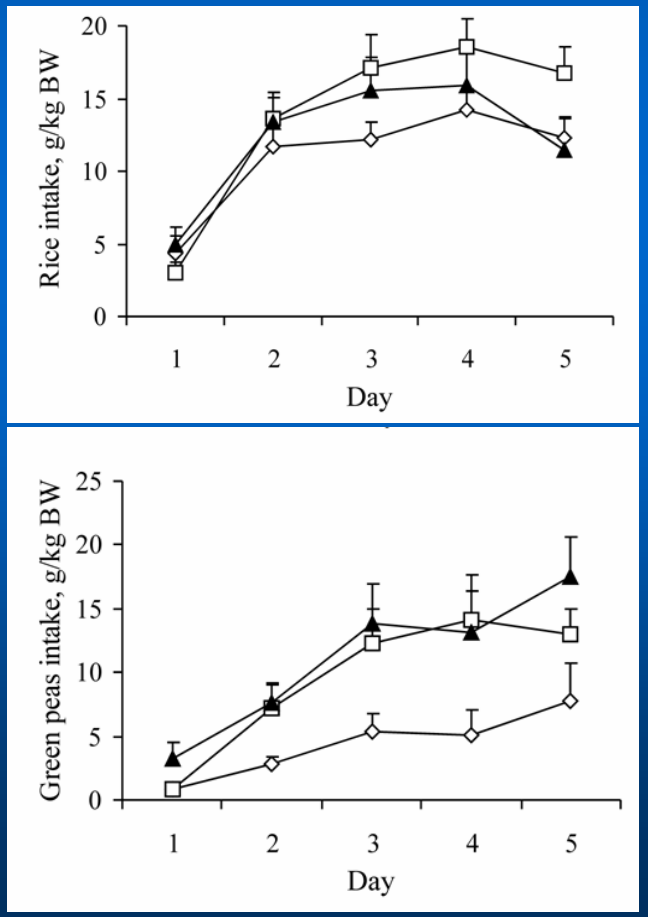
Catanese et al., In preparation

✓However, differences were not observed on the first day of testing, suggesting a similar initial neophobic response among treatments.

Novel Flavors



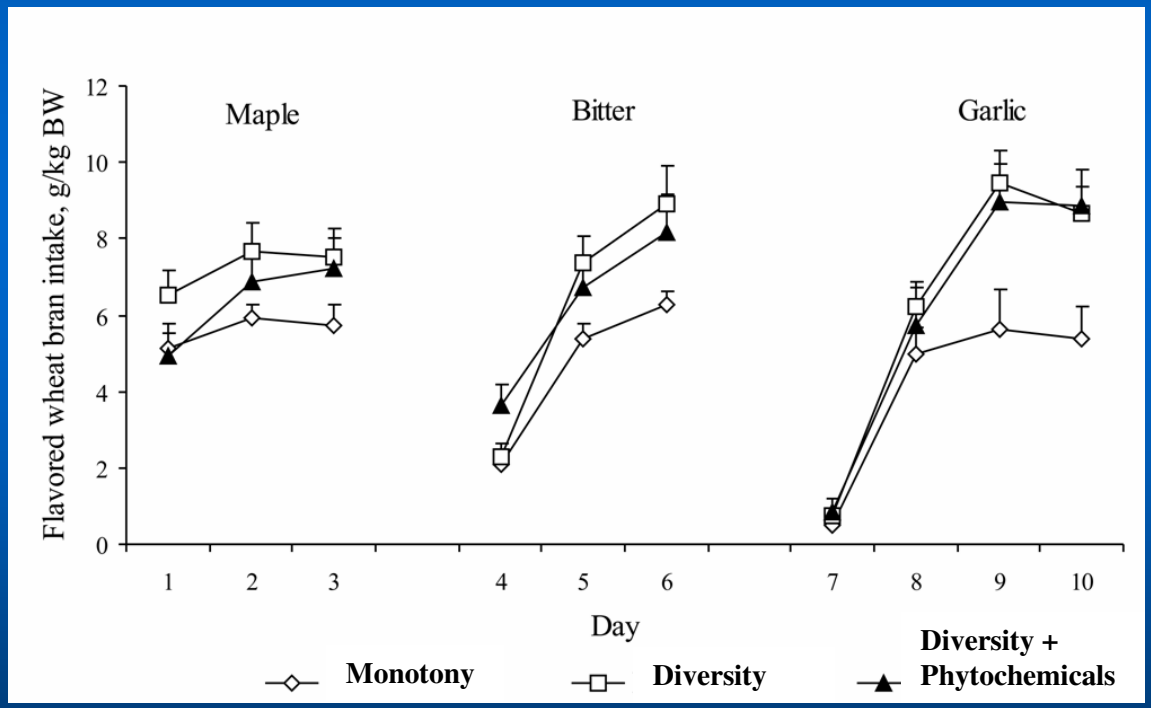
Novel Feeds



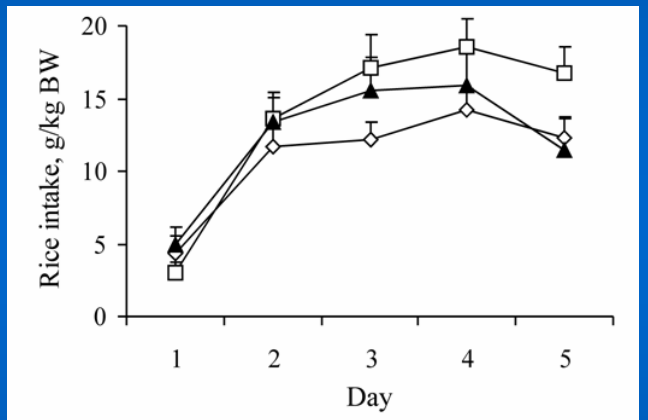
Catanese et al., In preparation

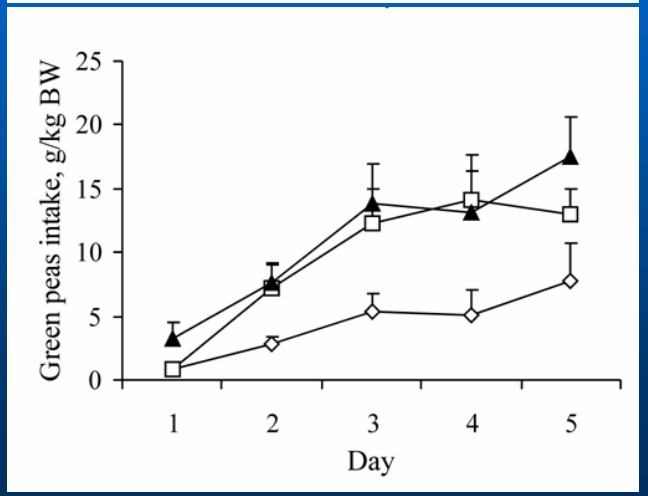
✓Thus, early exposure to food diversity affected the rate at which lambs accepted new feeds across time.

Novel Flavors



Novel Feeds

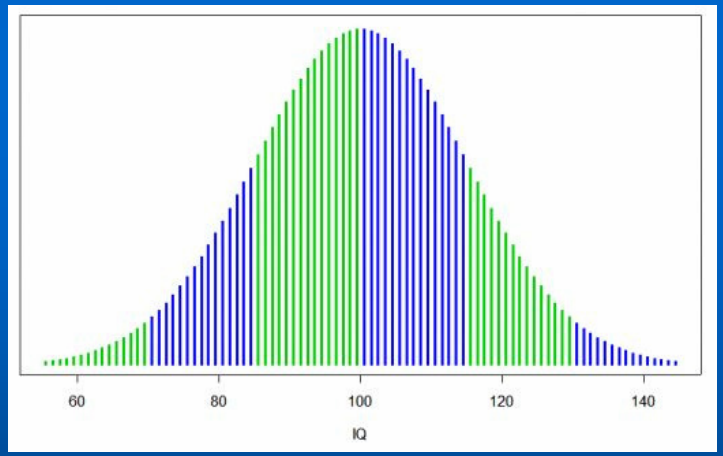




Catanese et al., In preparation

4- Differences among individuals

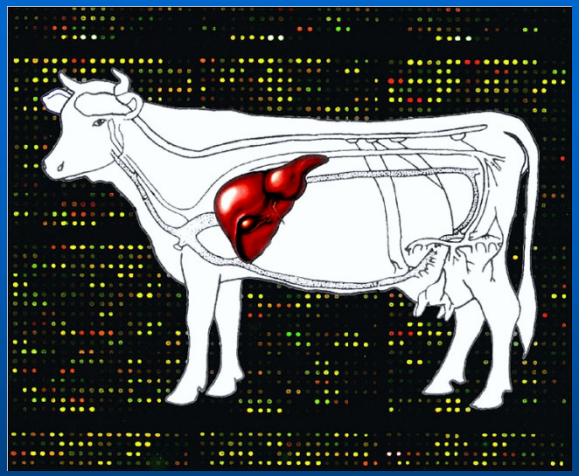
What traditionally has been considered adequate nutrition for the ***average*** animal may not be so for ***individuals in a group.***

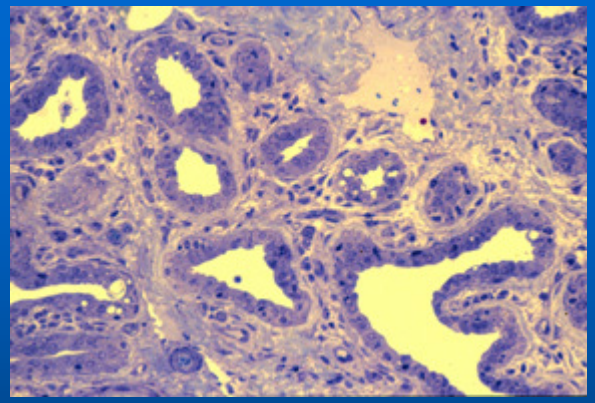


With the advent of statistics in the 20th century, great emphasis has been placed on assessing the response of the "average" animal to a ration.

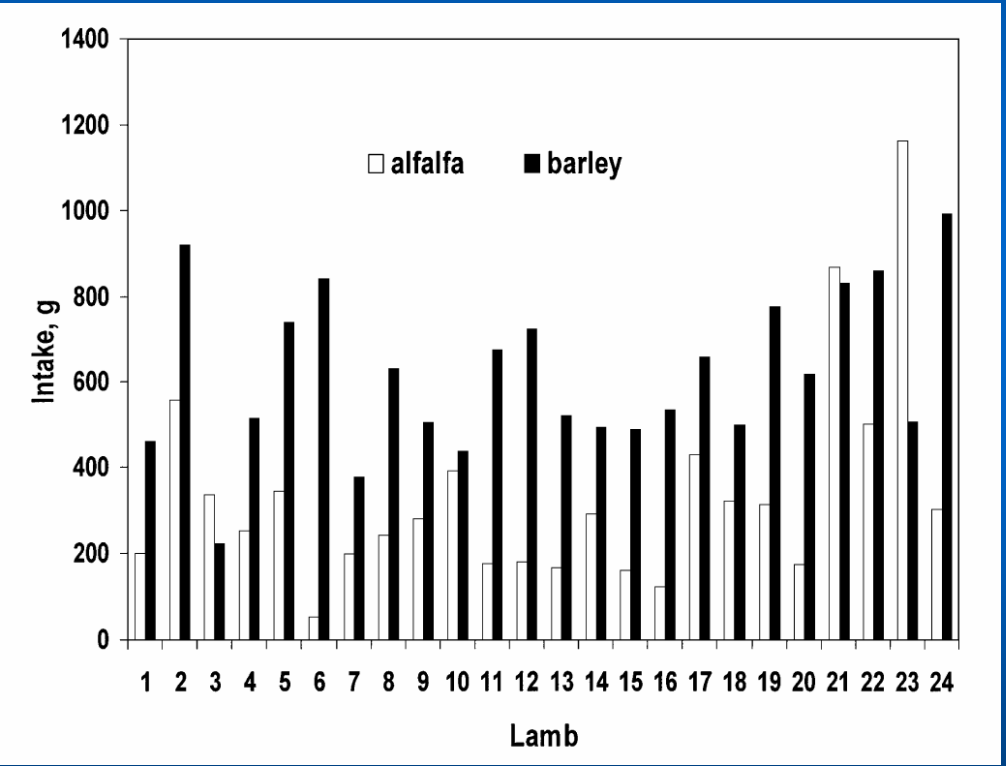
But the average animal does not exist

Differences among individuals in food intake and preference depend in part on variations in how animals are built morphologically and how they function physiologically.





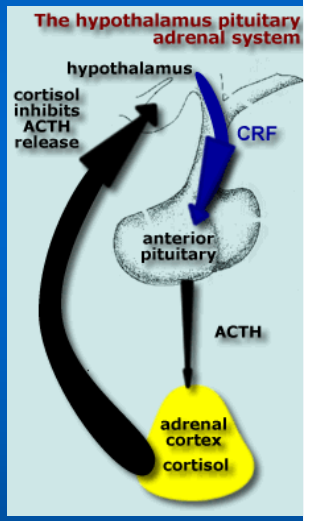
Marked differences are common even among uniform groups of animals in needs for nutrients and foraging preferences



Scott and Provenza, 1999

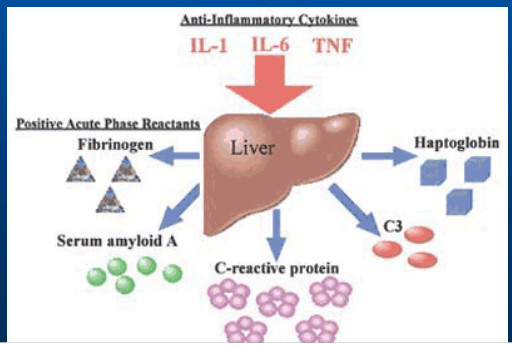
Stress due to a mismatch between ration and individual

If the "average" diet does not match the requirements of the individual, intake may decline and a stress response may appear.



✓Activation of the hypothalamic-pituitary-adrenal (HPA) axis → ↑Cortisol in plasma, saliva, feces.

✓Acute-phase protein (APP) response



In summary

Individuals are able to meet nutritional requirements and reduce fear to novel feeds and environments if they are offered the opportunity to do so: When offered a variety of feeds.

How do we incorporate these concepts into feeding systems?

It will imply a paradigm shift in the way animals are fed, recognizing their role as active players in the feeding system, as opposed to passive entities just responding to prescriptions and ration formulations.