# Physiological consequences of selection for increased performance in pigs

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# Resource Allocation

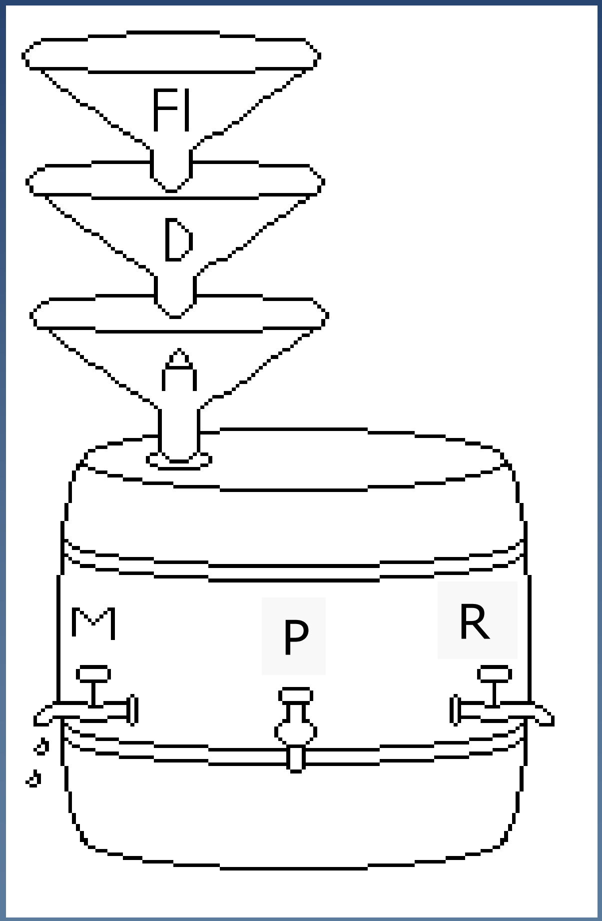
First law of thermodynamics: law of conservation of energy

= energy can not be created or destroyed, it can only be changed from one form to another

Energy from food = Energy in product + Loss



# Barrel model of energy balance:




**Input (in series):**

FI = Food Intake

D = Digestion

A = Absorption

**Output (parallel):**

M = Maintenance

P = production

R = Reproduction

## Resource Allocation Model:

Resources (R) allocated to processes **add** to give the total amount of resources consumed

R (Total) = R (Maintenance) + R (Production) + R (Reproduction) + R (Rest)

Rest = Activity + Other + 'Buffer' (reacting to stress & pathogens)

→ **Resources consumed by one process are no longer available for other processes**

- R(total) ↓ = R(A) ↓ + R(B) ↓

→ Proportional allocation

- R(total) ↓ = R(A) ↓ + R(B)

→ Disproportional allocation

- R(total) (↓) = R(A) ↓ + R(B) ↑

→ Preferential allocation / Trade off

Many interactions occur in the form of trade-offs

**Genes** = the instructions controlling maintenance, production and reproduction

This genetic potential can only be realized in an environment in which essential resources are adequately supplied!

Different environments place different loads on genotypes of a population

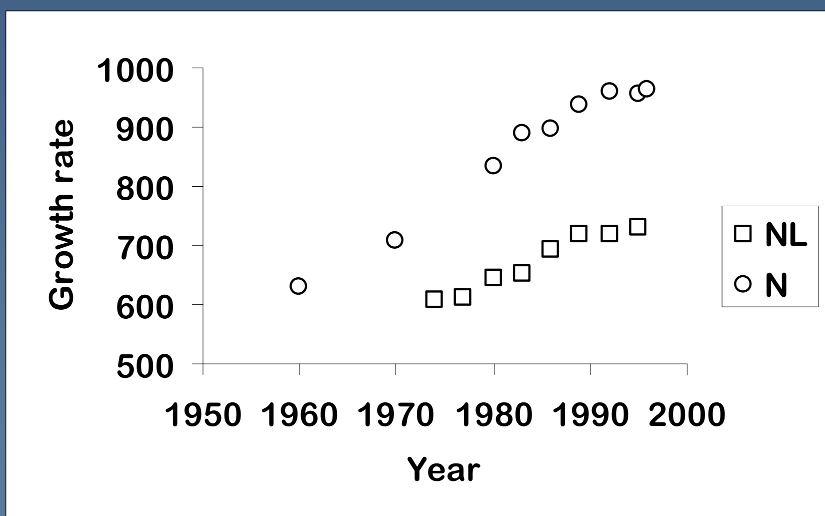
Different genotypes place different demands on environmental resources

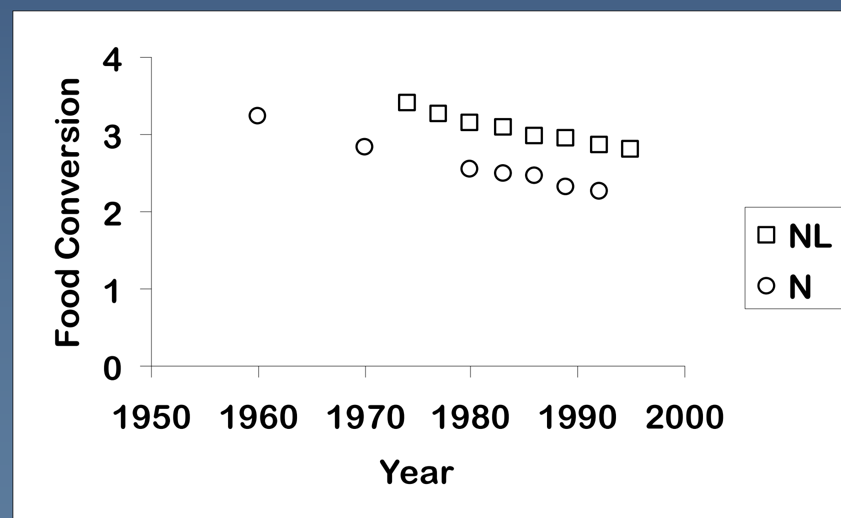
## Pig production

= selection for **high production efficiency**

= increased production but decreased food intake (increased efficiency)

→ We want increased output on our input

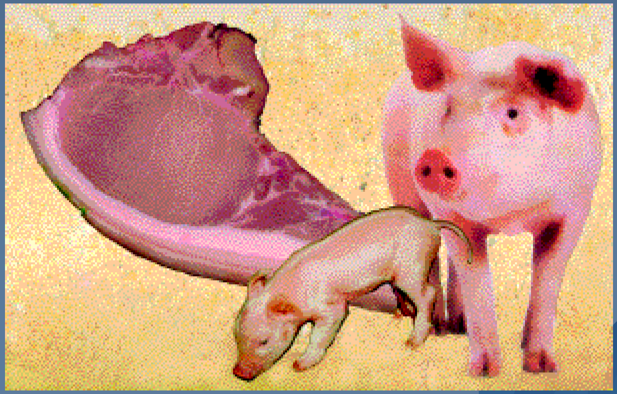


R (Total) = R (Maintenance) + R (Production) + R (Reproduction) + R (Rest)

If R (Total) does not increase,

↑ R (Production) = ↓ R (Other)

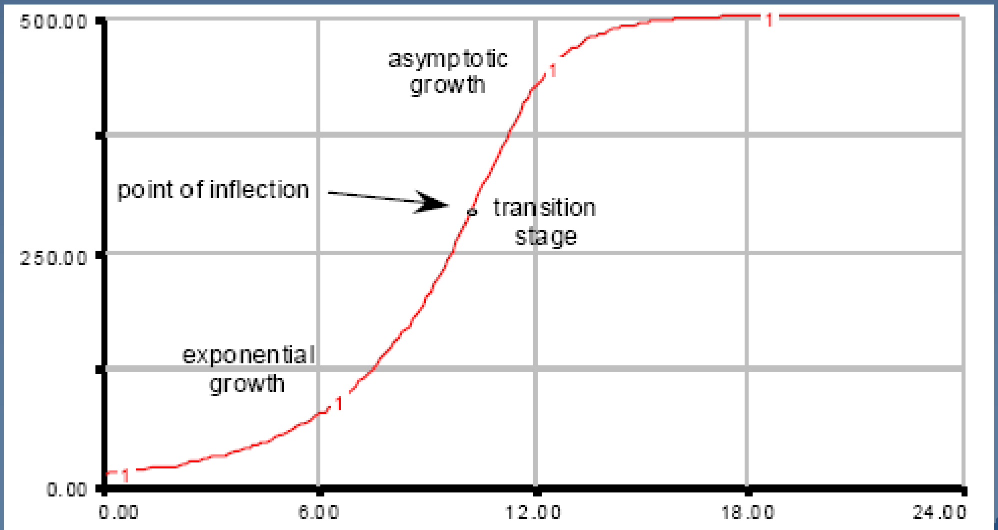


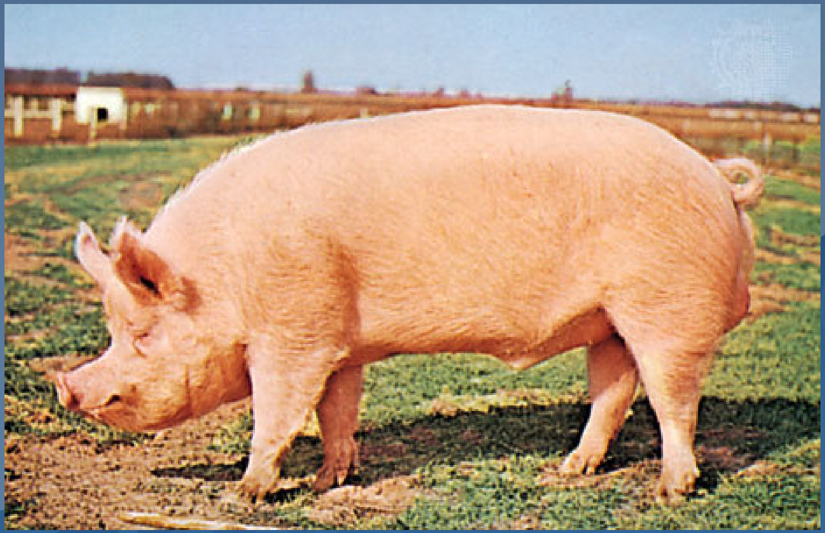
Because younger pigs grow faster:

Selection for increased growth rate at a fixed age or fixed body weight results in pigs that are physiologically younger at this age/weight

→ They have an increased body size

Pigs are 30% larger than 30 years ago



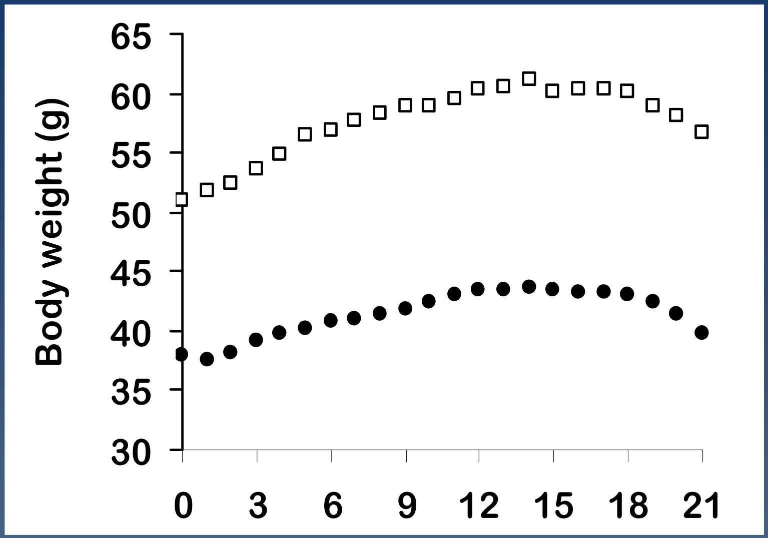



## Resource situation in modern lean and efficient pigs:

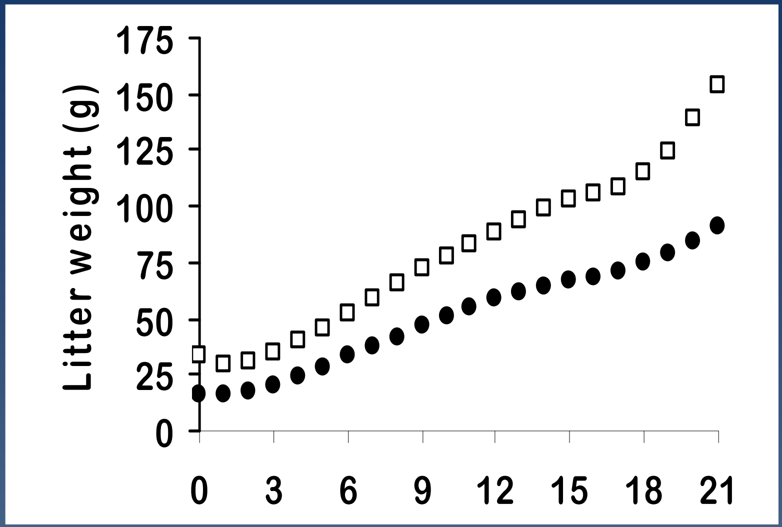
- Decreased feed intake capacity
- Reduced appetite
- Lower body fat reserves at parturition
- Are bred at physiologically younger age

Gilts are challenged simultaneously with the drive to grow, support pregnancy, sustain lactation, and rebreed after weaning

# Lactating mice:




(Days in lactation)




(Days in lactation)

| | C | S |
|---|---|---|
| MFI (g/d) | 4.7 | 6.1 |
| FI 14 (g) | 18.0 | 26.6 |

**At peak lactation, lactating females ate about 4 times MFI!**

## Lactating sows:

Even in the best management conditions, lactating sows lose body weight during lactation, even under ad libitum feeding conditions

→ Feed intakes of 6 to 8 kg of conventional feeds per day are hardly achieved under practical conditions

## Consequences of selection: Reproduction

Normal sow shows estrus between 4 and 7 days after weaning

But: may be 200 days or longer

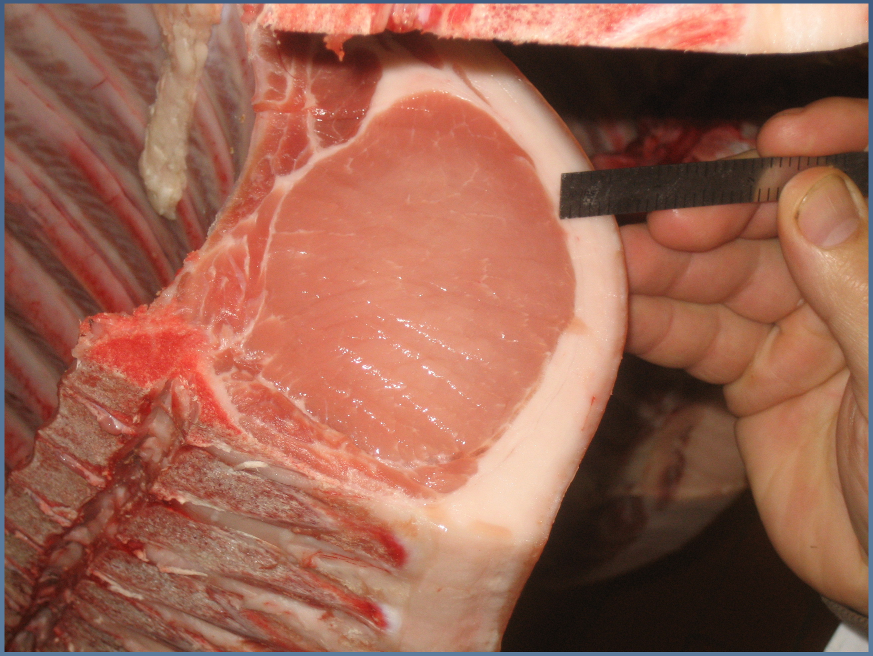
→ **Unfavorable genetic relationship between selected traits and rebreeding performance**

Gilts with higher lean % had genetically delayed onset of puberty, showed shorter pro-estrus

Gilts with higher growth rate had genetically delayed onset of puberty, had less ability to show standing reflex and shorter duration of standing estrus

**Indirect relationship: genetic variation in susceptibility to severe depletion of body reserves and stressors**

→ **A minimum % of body fat is required for the onset of estrus**



## Consequences of selection: Health

Selection for high lean tissue growth rate resulted in more leg weakness → worse osteochondrosis scores

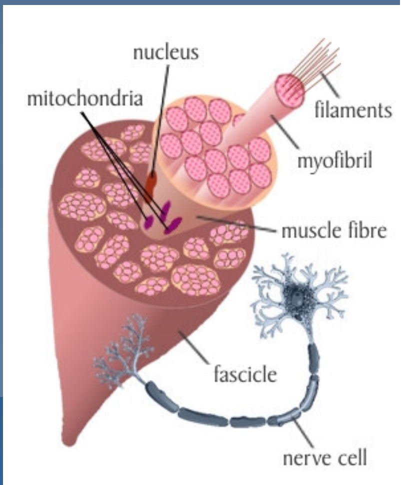
Adverse genetic correlation between fat depth and aggregate leg scores

## Consequences of selection: Meat

Domesticated pigs have less oxidative slow twitch muscle fibers than wild pigs

Oxidative capacity is lower and glycogen content higher

They have smaller mean fiber areas, a smaller number of capillaries per fiber, and lower oxidative enzyme activities



Fast twitch = brief high energy expenditure

Slow twitch = activities that are prolonged and require constant energy

**Domestication has resulted in a decreased ability to sustain environmental stresses**

**Natural trade-offs:**

One would assume a trade-off to occur when the animal approaches a limit to its metabolism

→ This is not the case

Metabolic sensors initiating the re-allocation of metabolic energy: homeorhetic regulation

= coordinated changes in metabolism to support a physiological state

Reallocation of nutrients towards mammary gland during lactation away from tissues not essential to lactation

Reallocation of nutrients towards activating the immune system during infection, tissue damage and stress

## Selection trade-offs:

When animals are genetically driven to produce at high levels, resources may be reallocated away from other processes

The animal may be left lacking in ability to respond to other demands, such as coping with disease and stress

Buffer capacities and traits not defined in the breeding goal may be the first ones to be affected, because they are given no importance

Most striking trade-offs in broiler chickens

In pigs: selection has been less intensive, for more traits and during fewer generations

**Why care?**

- Increasing consciousness among people
- Veterinary costs and costs of replacing animals may further increase
- Changing breeding programs may take five to ten years before genetic trends in commercial livestock are really changed

## What can we do?

◆ Modification of the environment to increase the amount of available resources

- increasing energy amount of feedstuffs or reducing environmental stress

→ Possibilities may be limited and costly and the population may become more dependent on the specific environment

- Selection for increased feed intake

## What can we do?

- Redefine the breeding goal into a broader perspective

- Breeding animals with a long economical (re)productive life at a production level that is economical without giving signs of disturbed welfare

→ Traits will have to be closely defined

→ Breeders may have to be satisfied with a slower increase in (re)production

## In conclusion ...

Cooperation between animal breeders and scientists in the development of a more sustainable breeding goal

Should include traits that we consider important and determine income from production besides production itself

⟶ Food intake capacity and appetite = increased production without diverting resources away from other processes

⟶ Fitness traits = health traits, traits related to stress (and welfare)

# Acknowledgements

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