

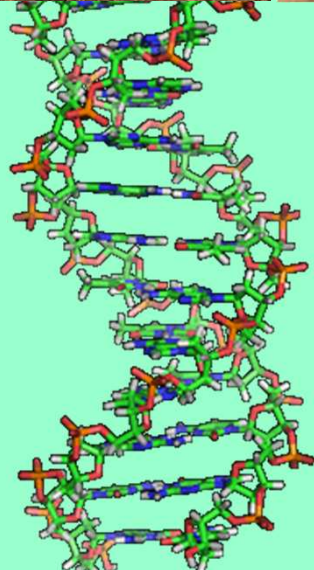
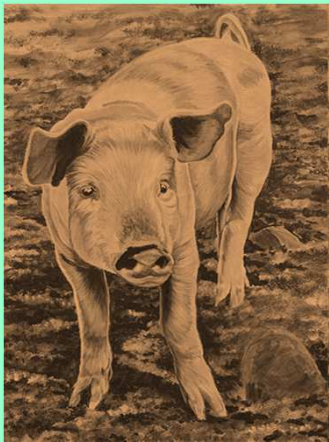


Domestic DNA

On the origin of livestock

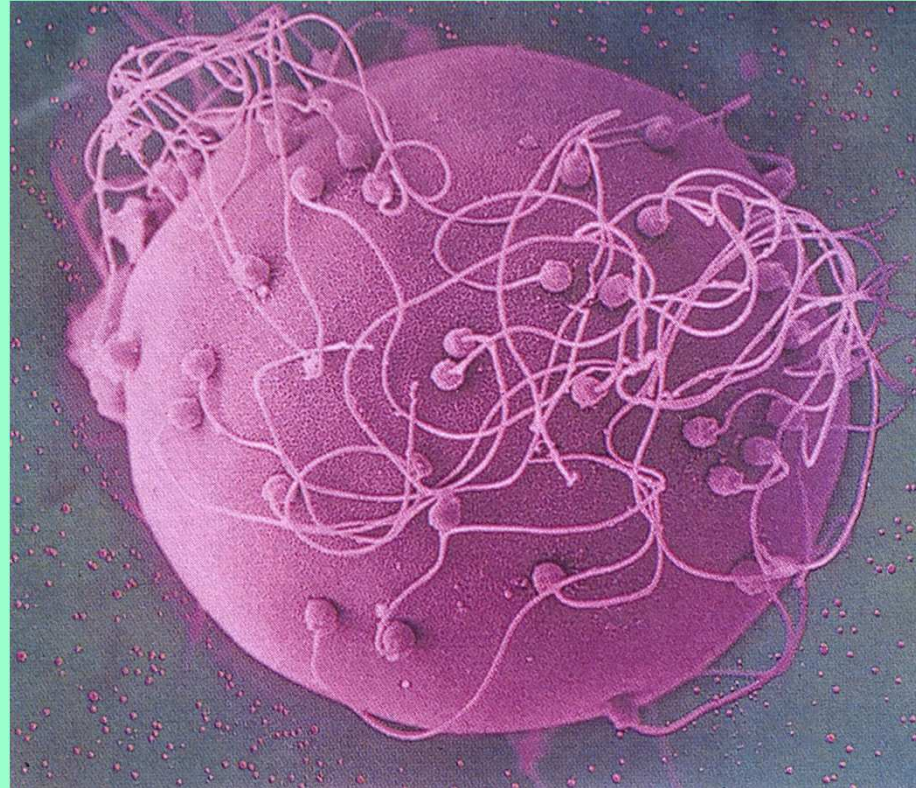
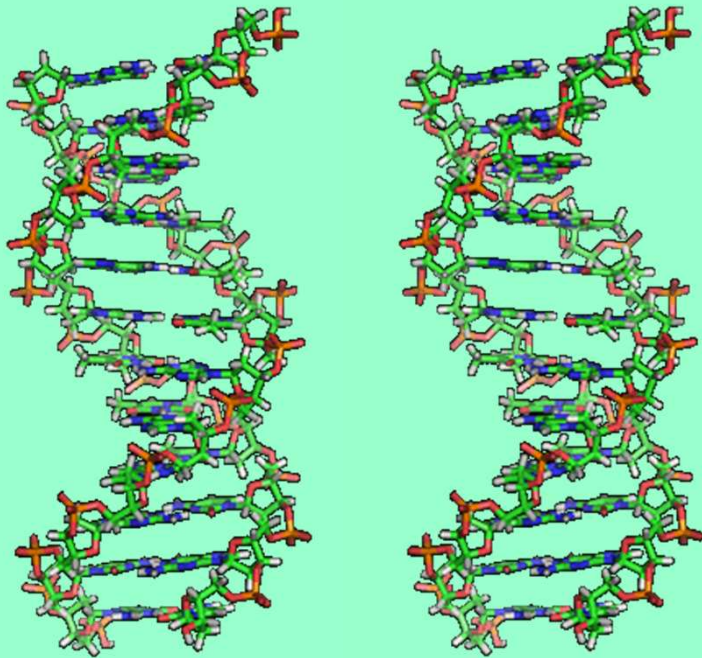


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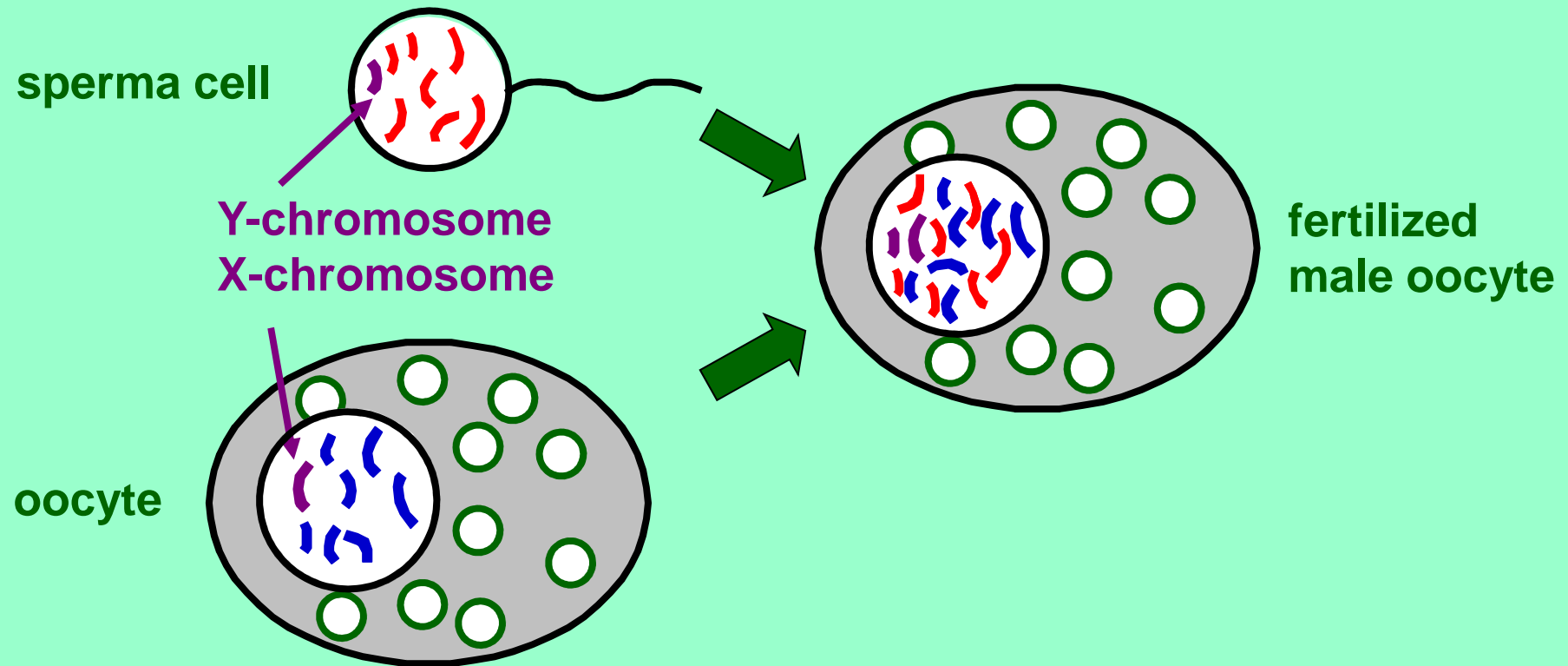
- ❑ DNA allows a reconstruction of the **history** of livestock, which is closely linked to our own history
- ❑ DNA analysis facilitates **genetic management** of livestock breeds

Transmission of DNA



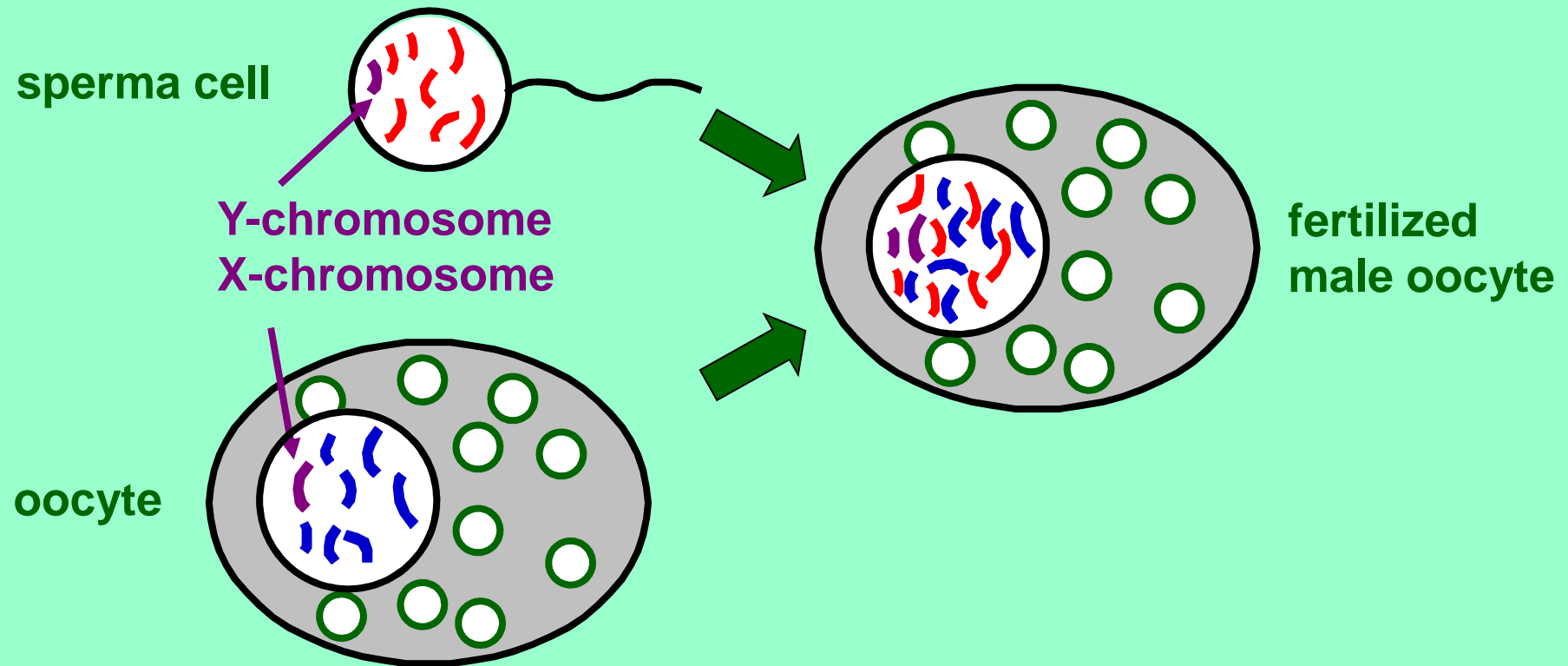
- Mammals are diploid: DNA comes from both parents
- Many sperm cells on oocyte
- One will penetrate and deliver its DNA

Transmission of DNA



- ⌋ paternal autosomal DNA
- ⌋ maternal autosomal DNA
- ⌋ male Y-chromosome: paternal transmission
- mitochondrial DNA: maternal transmission

Transmission of DNA



⌋ paternal autosomal DNA

⌋ maternal autosomal DNA

⌋ male Y-chromosome variants: origin of sires

○ mitochondrial DNA variants: origin of herds and flocks

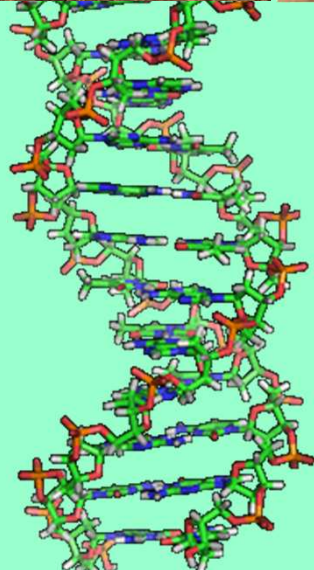
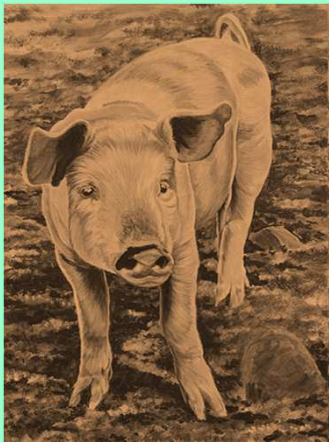


Domestic DNA

On the origin of livestock



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- DNA allows a reconstruction of the **history** of livestock, which is closely linked to our own history
- Each species has its own story**



Domestic DNA

On the origin of livestock

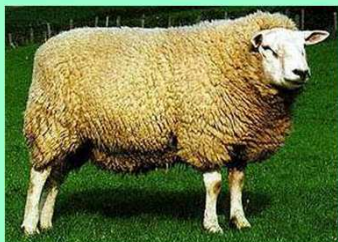


1. Domestication

- Excavations, mitochondrial DNA: First sheep, goats, pigs, cattle in Mesopotamia, 10.000 – 6.000 BC
- The first farmers, the first cities
- Towards modern society



Asian mouflon



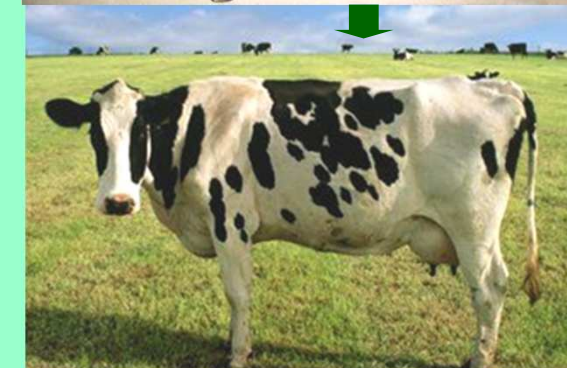
bezoar goat



wild boar



aurochs





Domestic DNA

On the origin of livestock



2. Migration

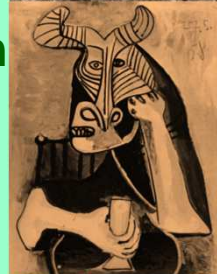
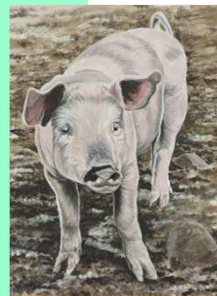
In Europe via two routes:
along Mediterranean coast
along Danube

3. Contact with wild relatives

Sheep, goat, horses: no wild relatives in Europe

Pigs: European wild boar replaced Asian imports

Cattle: ~ 1/1000 descends from aurochs cow, but role of aurochs bulls *a priori* likely





Domestic DNA

On the origin of livestock



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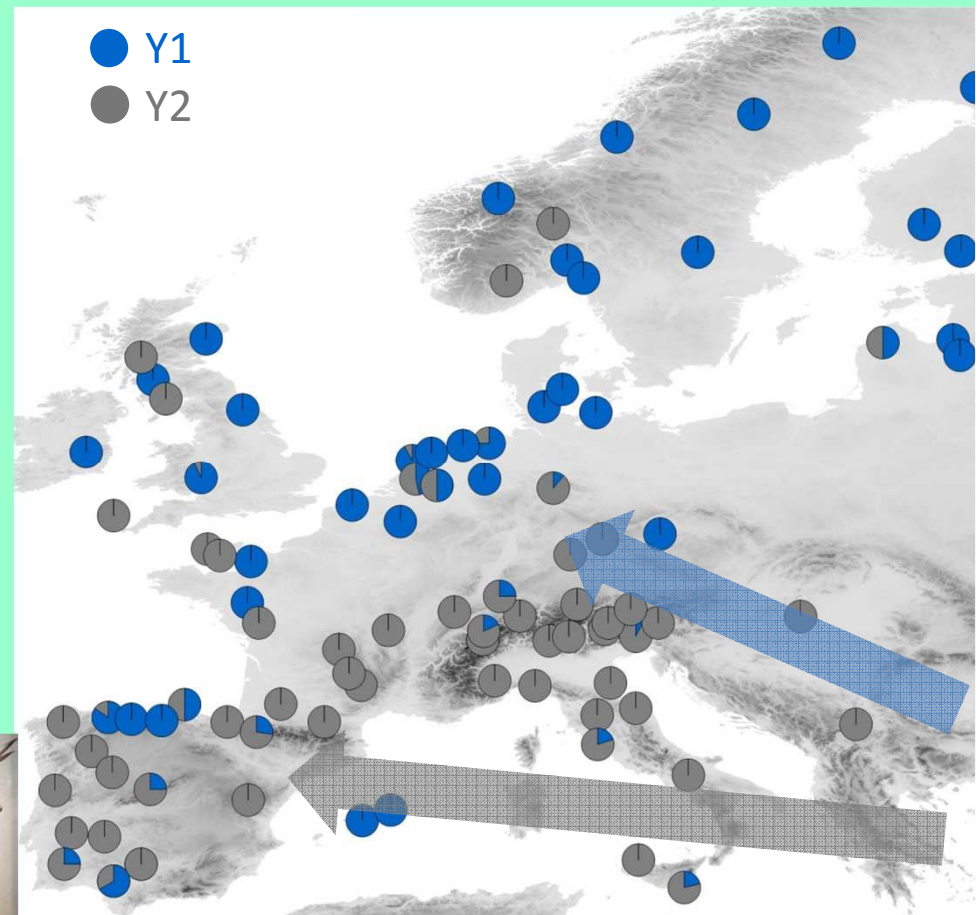
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Y-chromosomal variants:
clear Y1-Y2 north-south contrast

Y1 from aurochs?





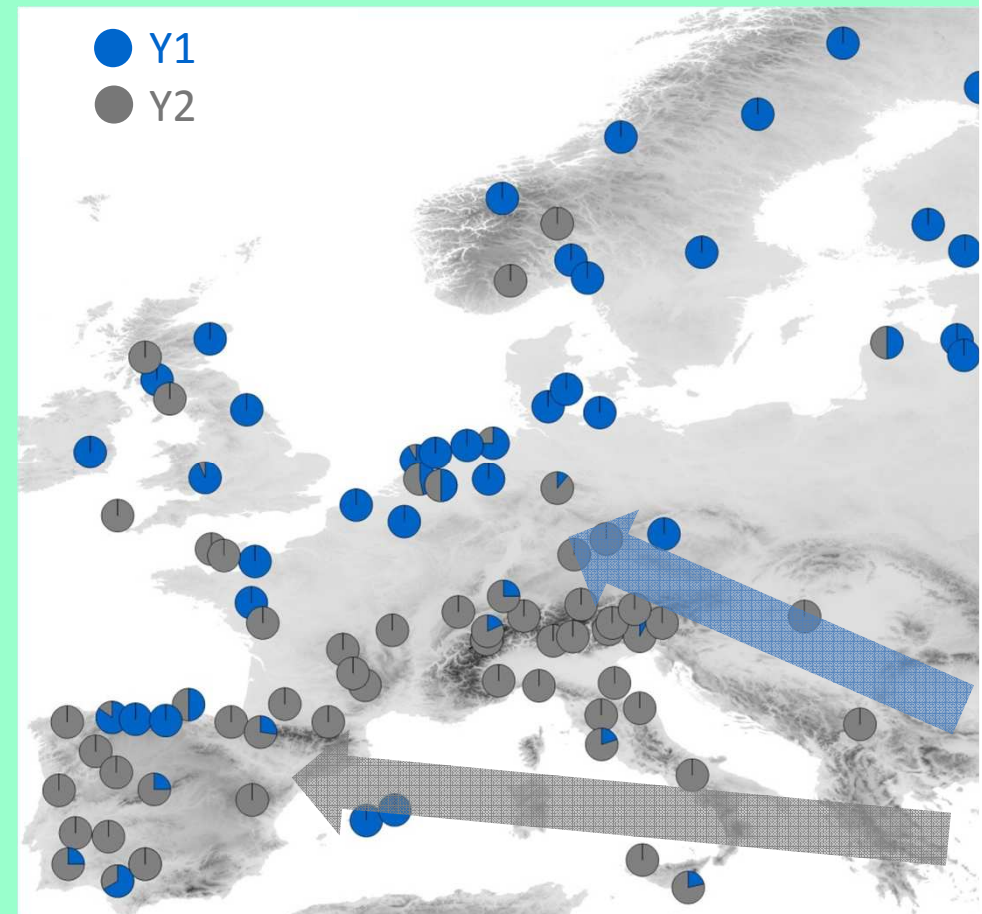
Domestic DNA

On the origin of livestock



4. Specialization, since 200 yr breed formation

Worldwide now 1000s of livestock breeds





Domestic DNA

On the origin of livestock



4. Specialization, since 200 yr breed formation

Worldwide now 1000s of livestock breeds

Cattle, autosomal DNA: clear
north-central-south contrast

2 major types of dairy cattle
evolved separately



Germanic



Helvetian, already in
Roman era

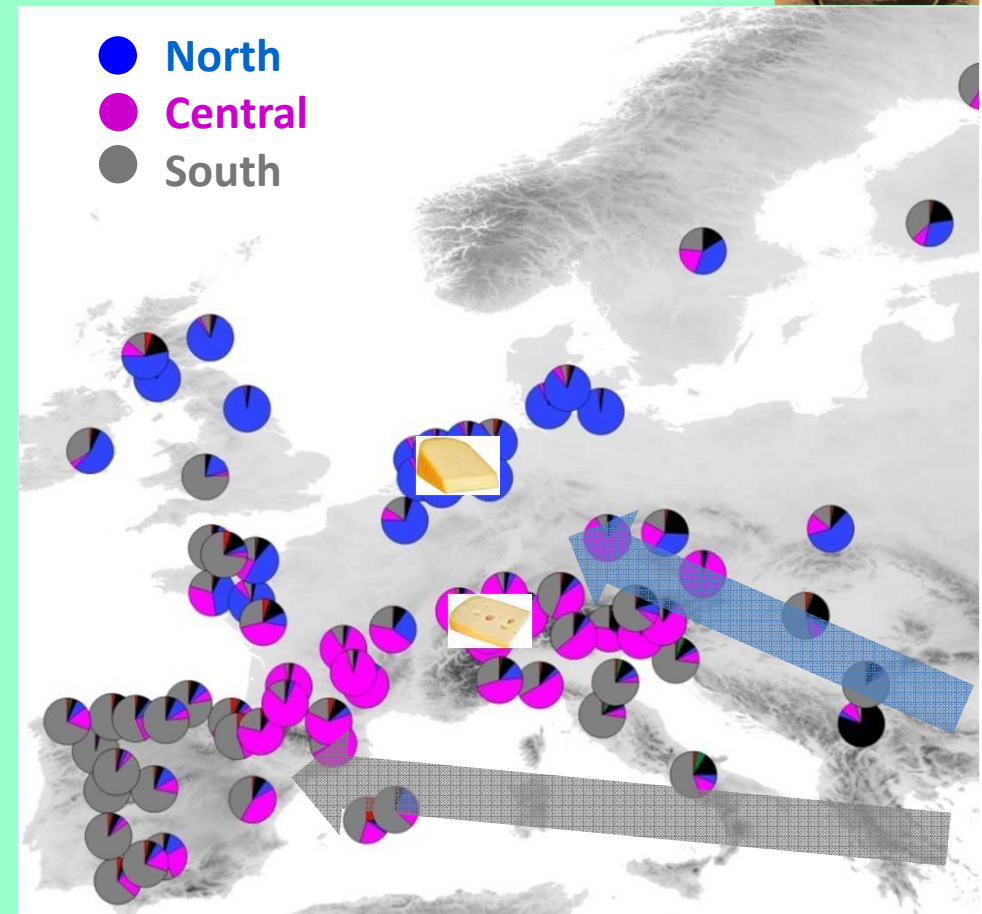
Sheep: original hair sheep were
largely replaced by wool sheep



Mouflon



Merino





Domestic DNA

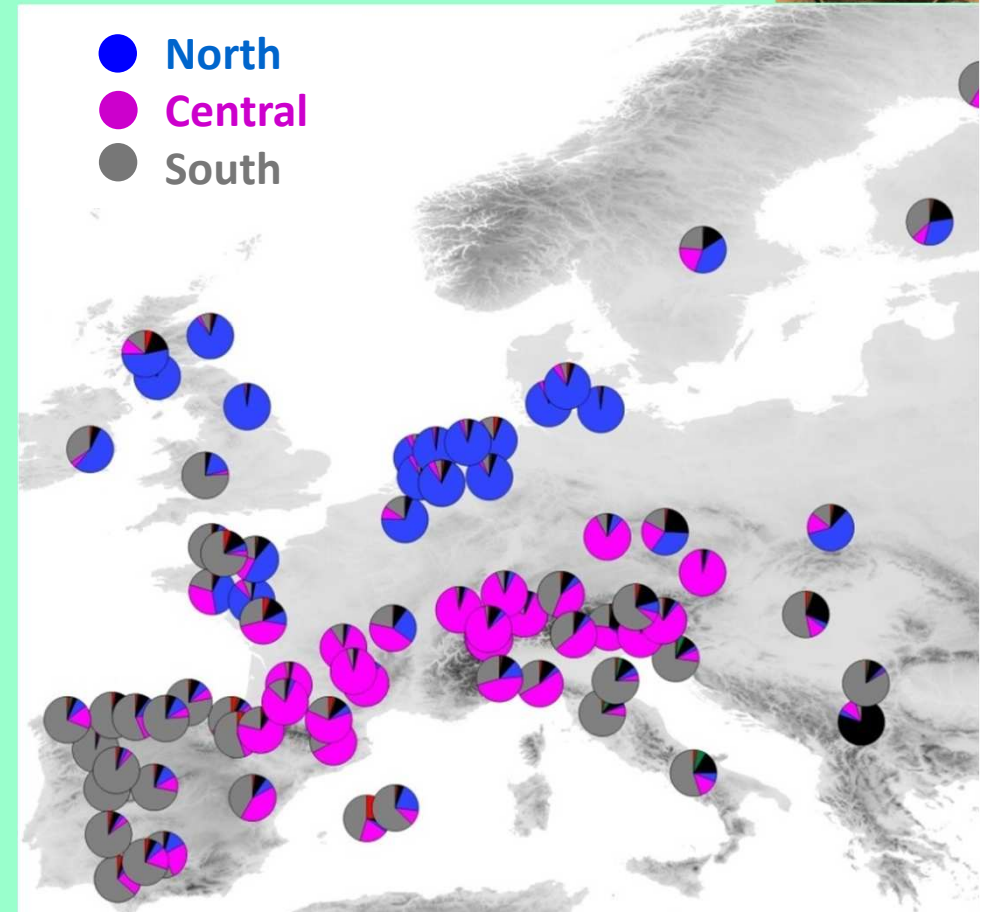
On the origin of livestock



4. **Specialization**, since 200 yr breed formation
5. **Cross-breeding**
Not all breeds are authentic landraces



Pigs: large-scale 19th century crossing with Chinese Meishan





Domestic DNA

On the origin of livestock



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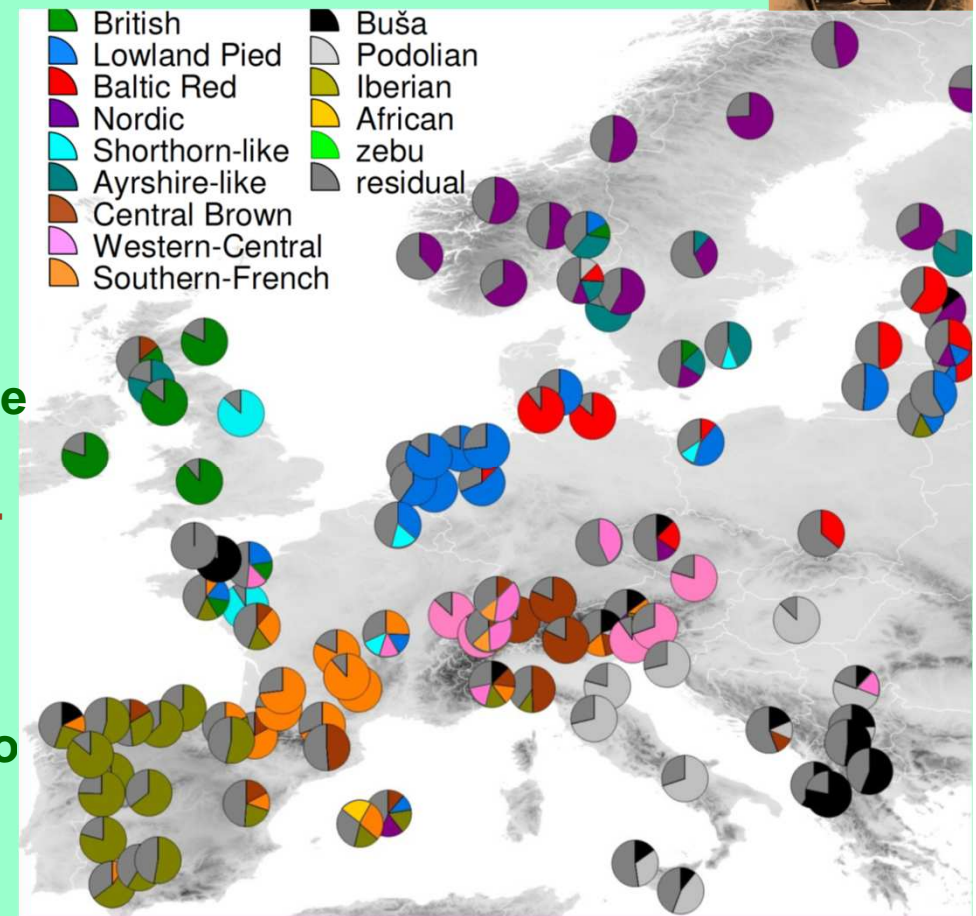


Pigs: large-scale 19th century crossing with Chinese Meishan



Cattle: dairy breed clusters emerge by spreading of popular breeds: **black-pied**, **red**, **Shorthorn**, **alpine-brown**, **alpine spotted**

Sheep: in Middle Ages spreading of British and then Spanish Merino wool sheep. **New data!**



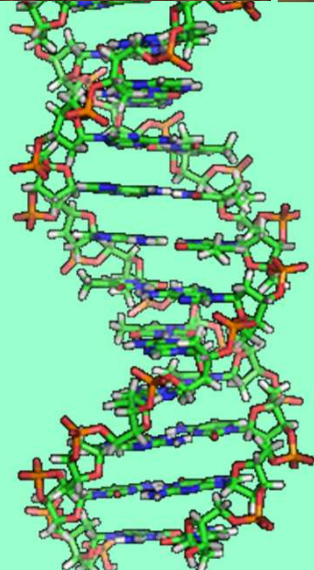
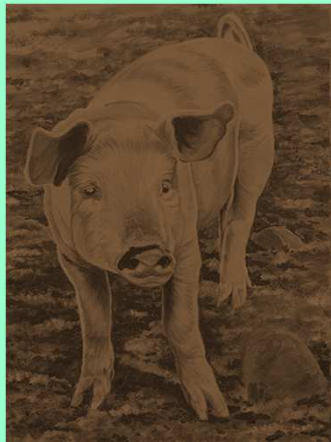


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- DNA allows a reconstruction of the **history** of livestock, which is closely linked to our own history

Recent results with sheep



International Sheep Genomic Consortium



Sheep DNA

On the origin of wool



- **Mitochondrial DNA**
 - » Southwest Asian origin
- **31 autosomal microsatellites, 1748 sheep, 57 breeds**
 - » SW Asian/SE European/SW-European/NW-central clusters
 - » Within West-Europe weak geographic differentiation
 - » Loss of diversity from southeast to northwest





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On the origin of wool



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- 31 autosomal microsatellites, 1748 sheep, 57 breeds
 - » SW Asian/SE European/SW-European/NW-central clusters
 - » Within West-Europe weak geographic differentiation
 - » Loss of diversity from southeast to northwest
 - ☹ Uneven breed representation
 - ☹ Microsatellite markers not adequate
- 50.000 single-nucleotide polymorphisms (SNPs), 2819 sheep, 74 breeds from 5 continents + 55 wild or feral sheep



Sheep 50K SNP

On the origin of wool



SMF0018	GG	GG	AG	GG	AA	GG	GG	GG	GG	GG	GG	AG	GG	GG	GG	AG	GG	AA	AG	AA	AG	AG	GG	AA	AG	AG	AA	GG	GG
SMF0003	AG	GG	GG	GG	AA	GG	GG	GG	AG	GG	AA	AG	GG	GG	GG	AG	AG	AG	AA	AA	GG	AG	AG	AA	AA	AG	AG	AG	AG
SMF0019	GG	GG	AG	GG	AA	AG	GG	GG	GG	GG	AG	GG	GG	AG	GG	AG	AA	AA	AG	AA	AG	AG	GG	AA	AG	AG	AA	GG	GG
SMF0027	AA	GG	GG	GG	AG	AG	GG	GG	AA	GG	GG	GG	GG	AG	GG	AA	AA	AG	AG	AA	GG	AG	GG	GG	AG	AG	AG	AG	GG
SMF0004	AG	GG	GG	AG	AA	GG	GG	GG	AG	AG	AG	GG	GG	AG	GG	GG	AA	AG	AA	AA	AG	GG	GG	AA	AG	GG	AG	GG	GG
SMF0012	AG	GG	AA	GG	AA	AG	GG	GG	GG	GG	AG	GG	GG	GG	GG	AG	AA	AG	AA	AA	AG	AG	GG	AA	AG	GG	AA	00	AG
SMF0020	GG	GG	AG	GG	AA	GG	GG	GG	AG	GG	AG	AG	AG	AG	GG	AA	AA	AA	GG	AG	GG	AG	GG	AG	AG	AA	AG	AG	AG
SMF0005	GG	AA	AG	GG	AG	AG	GG	GG	AG	GG	AG	AG	GG	GG	GG	AA	AA	AG	AG	AA	GG	AG	GG	AG	GG	AG	AA	AG	AG
SMF0013	GG	GG	GG	GG	AG	GG	GG	GG	AG	AG	AA	GG	GG	AA	AG	AG	AG	AA	AG	AG	GG	AA	GG	AA	AA	AG	AG	GG	AG
SMF0021	GG	AG	AG	GG	AG	AG	GG	GG	AA	AG	AG	AG	GG	GG	GG	AG	AA	AG	AA	AA	GG	AG	GG	AA	AG	AG	AG	AG	GG
SMF0006	AA	AG	GG	AG	AA	GG	GG	GG	AA	GG	AA	AG	GG	GG	AG	AG	AG	AG	AG	AG	GG	AG	AG	AA	AG	AG	AG	AA	AA
SMF0014	AG	AG	AG	GG	AG	GG	GG	AG	GG	GG	GG	AG	GG	AG	GG	AG	AA	GG	AG	AA	GG	GG	AG	AG	AA	GG	GG	GG	GG
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SMF0026	AA	GG	GG	GG	AG	GG	GG	GG	AG	GG	GG	GG	GG	AG	GG	AA	AA	AG	AG	AA	GG	AA	GG	AG	AG	GG	AG	GG	GG
SMF0028	GG	GG	GG	GG	AG	GG	GG	GG	GG	GG	AG	GG	GG	GG	AG	AG	AA	AA	AA	AA	GG	AA	GG	AA	AA	GG	AG	AA	AG
SMF0007	GG	AG	GG	GG	AG	AG	GG	AG	GG	GG	AG	AG	GG	GG	GG	AG	AA	GG	AG	AA	GG	GG	AA	AG	AA	AG	GG	GG	GG
SMF0023	GG	GG	GG	GG	AG	GG	GG	AG	AG	AG	GG	AG	GG	AA	GG	GG	AA	GG	AA	AA	AG	AG	AG	AG	GG	AG	AG	AG	AG
AMF0001	AA	GG	GG	GG	AA	GG	GG	GG	GG	AG	AG	GG	AG	AA	GG	AG	GG	00	GG	GG	GG	AG	GG	AG	GG	GG	00	AA	AA
AMF0003	AA	GG	GG	AA	AG	GG	GG	00	AA	00	GG	GG	GG	GG	GG	AA	AA	AA	GG	AA	GG	GG	GG	AA	AA	GG	AA	GG	AA
AMF0004	AA	GG	GG	GG	AG	GG	GG	AG	GG	AA	GG	GG	GG	AA	AG	AG	GG	AA	GG	AG	GG	AG	AG	AA	AG	GG	AG	AG	AA
SOA5147	GG	GG	GG	GG	00	AG	GG	GG	AA	GG	AG	AA	GG	AG	AG	00	GG	GG	AG	00	AG	00	00	GG	GG	00	00	AG	00
SOA0904	AG	GG	GG	GG	00	GG	GG	GG	GG	GG	AG	AG	GG	AG	AG	00	GG	GG	GG	00	AA	00	00	GG	AG	00	00	GG	00
SOA2143	GG	GG	GG	GG	00	GG	GG	GG	AG	GG	GG	AA	GG	AG	GG	00	GG	AG	GG	00	AA	00	00	GG	GG	00	00	AG	00
SOA1952	GG	GG	GG	GG	00	GG	GG	GG	AG	GG	GG	GG	GG	AA	GG	00	GG	AG	AG	00	AG	00	00	GG	GG	00	00	GG	00
SOA2623	GG	GG	GG	GG	00	GG	GG	GG	GG	GG	GG	AA	GG	AA	AG	00	GG	GG	AG	00	AG	00	00	GG	GG	00	00	GG	00
SOA2624	GG	GG	GG	GG	00	GG	GG	GG	AG	GG	AG	AA	GG	AG	AG	00	GG	AA	AG	00	AG	00	00	GG	GG	00	00	AG	00
SOA2631	GG	GG	GG	GG	00	GG	GG	AG	AG	GG	GG	AG	GG	AG	GG	00	GG	AG	GG	00	AA	00	00	AG	GG	00	00	GG	00
SOA4103	GG	GG	GG	GG	00	GG	GG	GG	AG	GG	GG	AA	GG	AG	GG	00	GG	AG	AG	00	AG	00	00	GG	GG	00	00	AG	00
SOA2536	GG	GG	GG	GG	00	GG	GG	GG	AA	GG	AG	AA	GG	AG	GG	00	GG	GG	AG	00	AA	00	00	GG	AG	00	00	AG	00



Sheep 50K SNP

On the origin of wool

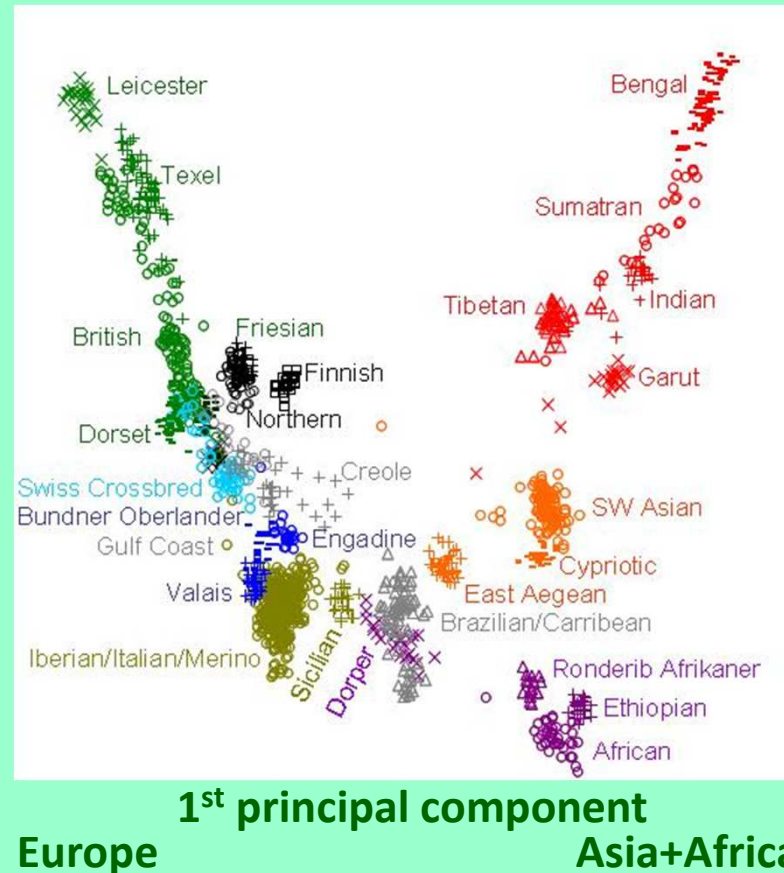


A. Coordination analysis » division of variation over principal components » 2D projection of sheep

diverged

2nd principal component

diverse



Asia
SW Asia
Africa
American
Spanish
Swiss
Swiss crossbred
N Europe
English

» Geographic clustering of sheep » global view of diversity

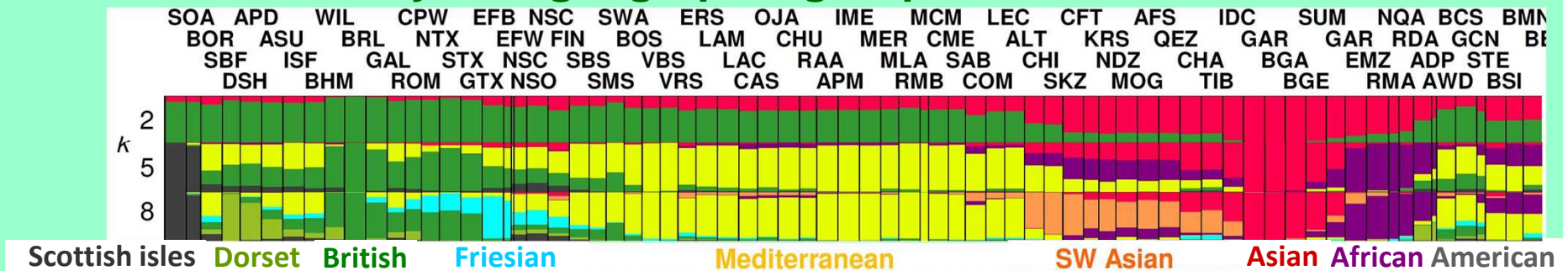


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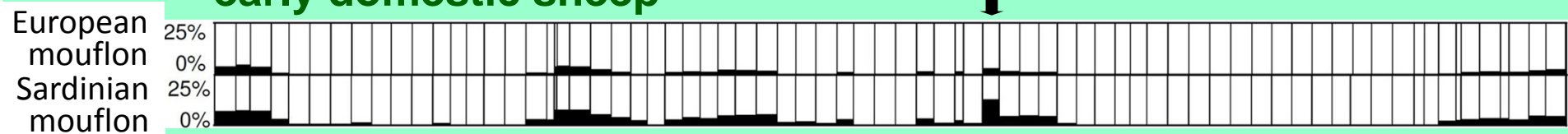
B. Cluster analysis » geographic groups of related breeds



» ancestral gene pools

Hybrid
Dorper

Supervised clustering with feral mouflons, descending from early domestic sheep



» remnants of most primitive sheep mainly in northern Europe





Sheep 50K SNP

On the origin of wool



C. Phylogenetic **networks** representing genetic distances

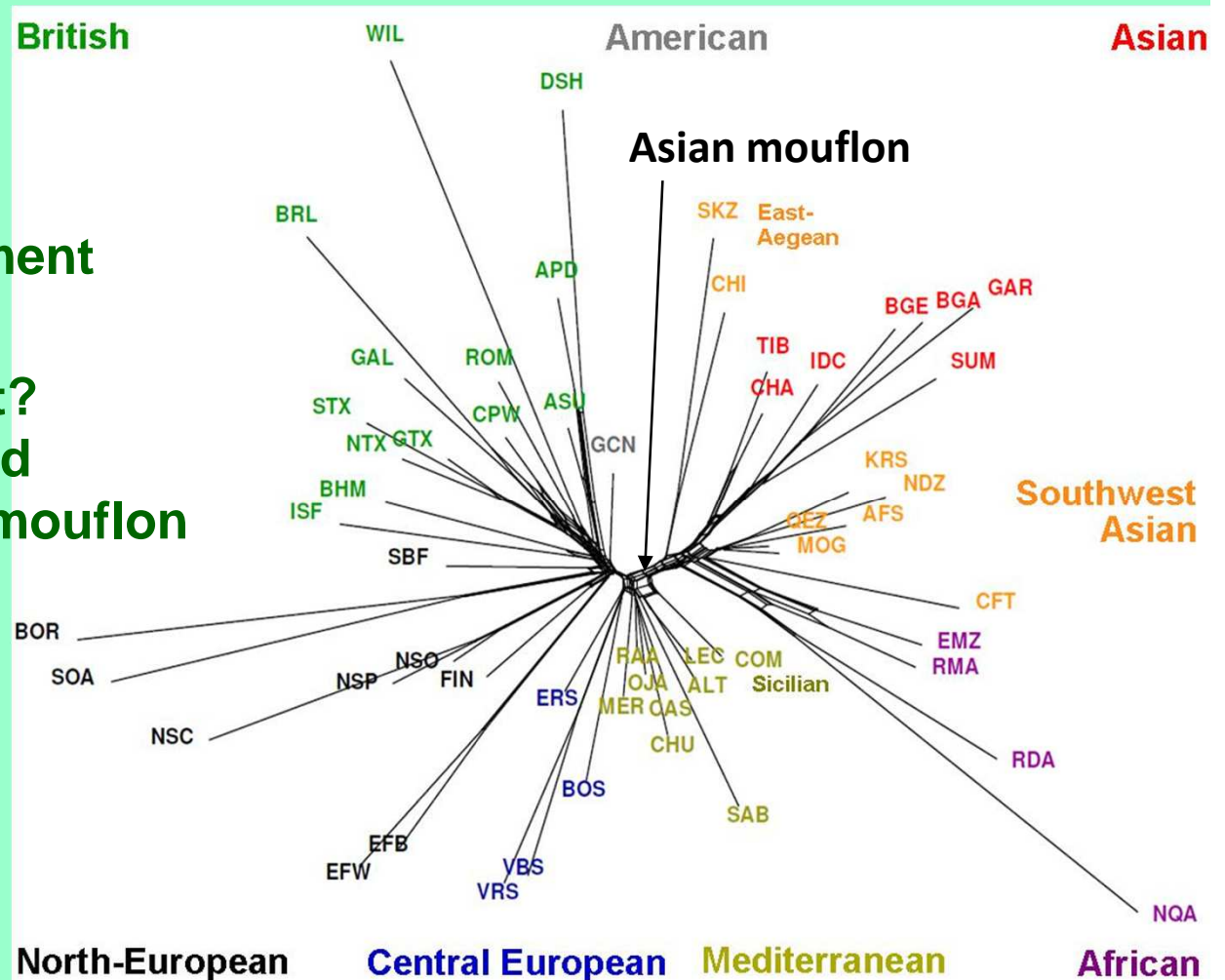
- » **lines of descent** of 'pure' breeds
- » geographic clusters

Branch lengths

- » breed development

Where is the root?

At position of wild ancestor: Asian mouflon



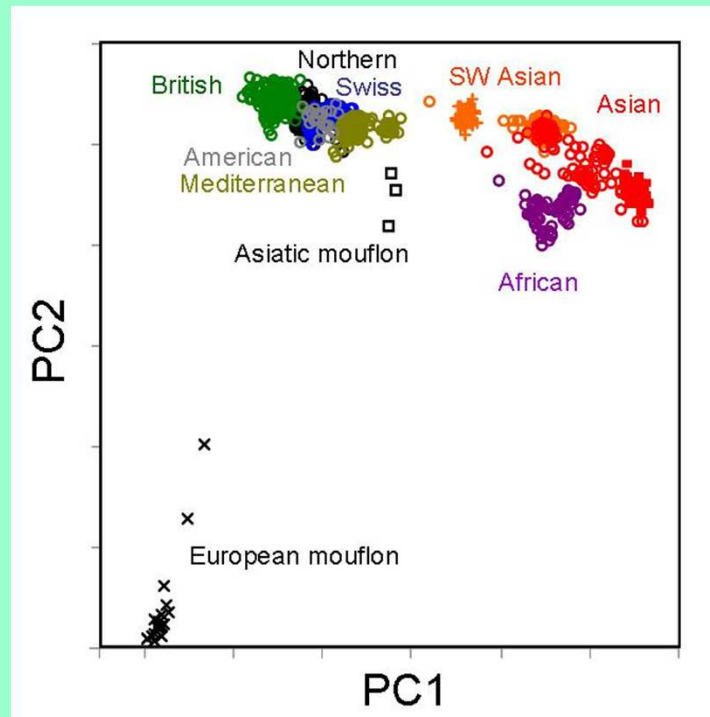


Sheep 50K SNP

On the origin of wool



Coordination analysis of feral and wild mouflon



- **Position of wild ancestor Asian mouflon:**
near South Italian and Greek breeds, not in SW Asia!
» **most breeds descend from Southern-Italian/Greek sheep**



Sheep 50K SNP

On the origin of wool



- Primitive hair sheep were later replaced by wool sheep, but when and where?



- Columella (4-70): during Roman era still many hair sheep

- Plinius the Elder (25-79), *Naturalis Historia* 8, 190:

Lana autem laudatissima Apula et quae in Italia Graeci pecoris appellatur, alibi Italica - - - Apulae breves villos nec nisi paenulis celebres; circa Tarentum Canusiumque summam nobilitatem habent.

[The most praised wool is that of Apulia, which in Italy is named the Greek sheep wool, but in other countries is named Italian - - - The wool of Apulia is of a short staple, and specially in request for cloaks and mantles, and nothing else. About Tarentum and Canusium, the richest of this kind are found.]



- Exactly where SNPs place the origin of sheep!
- Tarentine sheep exported to Syria, Black Sea, Spain, Britain

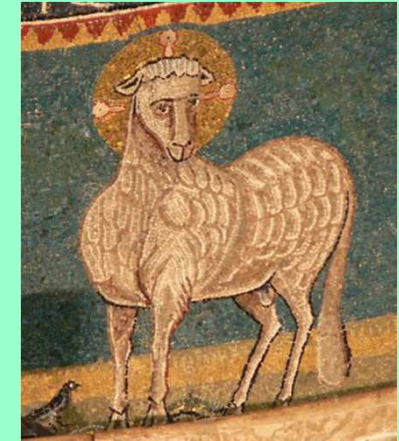


Sheep 50K SNP

On the origin of wool



- Wool trading was a vital component of the Roman economy
- Hypothesis: demand of high-quality wool drove export and expansion of Southern Italian wool sheep. These became the ancestors of most sheep around the world.





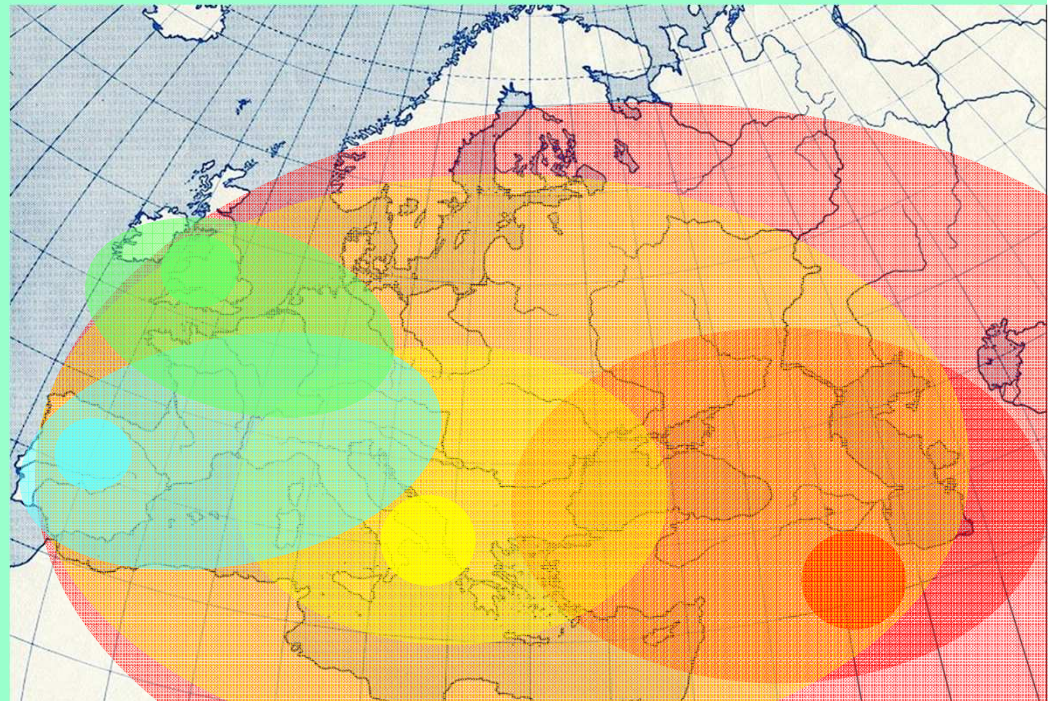
Sheep 50K SNP

On the origin of wool



➤ Successive expansions of profitable types of sheep.

1. **8.000-10.000 BCE**
Primitive hair sheep
2. **Roman period:**
Tarentine wool sheep
3. **From early Middle Ages:**
English wool sheep
4. **From late Middle Ages:**
Spanish Merino wool sheep



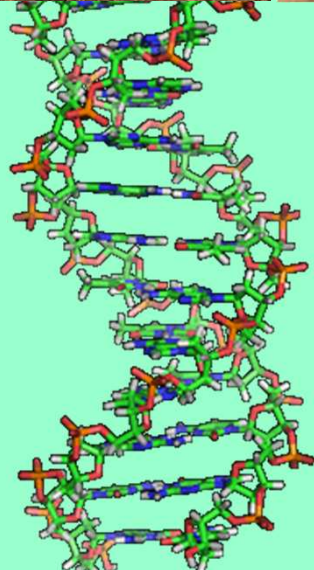
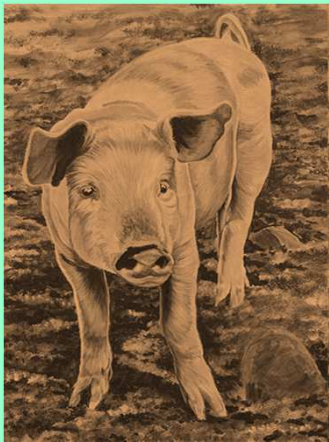


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On the origin of livestock



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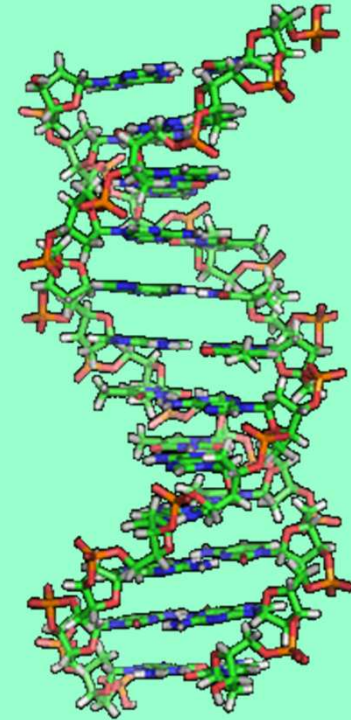


Domestic DNA

Molecular conservation of breeds



- Original **justification** of diversity research
- DNA may indicate a **high diversity**
 - » valuable for conservation
 - often primitive breeds near domestication site
- DNA may indicate a **separate history**
 - » valuable uniqueness
 - Italian Chianina cattle, Scottish Soay sheep, etc.
- DNA may indicate a **recent origin**
 - » conservation less urgent
 - many synthetic or upgraded breeds
- **DNA does not (yet) always provide an answer**





Domestic DNA



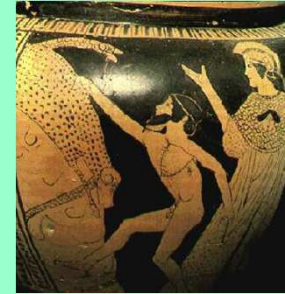
Non-molecular conservation of breeds

➤ **Valuable traits:**

E.g.: The Golden Fleece

Local adaptation

Does not imply large DNA diversity



➤ **Cultural heritage, tradition, but:**

- Most breeds only few 100 years old
- Most breeds of mixed origin
- Conserve the phenotype, but not '**genetic purity**'.
E.g.: Dutch Belted influenced by Galloway



➤ **Strict genetic isolation harmful for animal health**

The conservation dilemma of the **Friesian horse**:

- unique appearance
- despite careful management, more inbred than any other horse breed » **genetic disorders**
- eradication of genetic defects » more inbreeding!
- **cross-breeding**: loss of traits, but avoidable?

Similar problems in many **dog breeds**



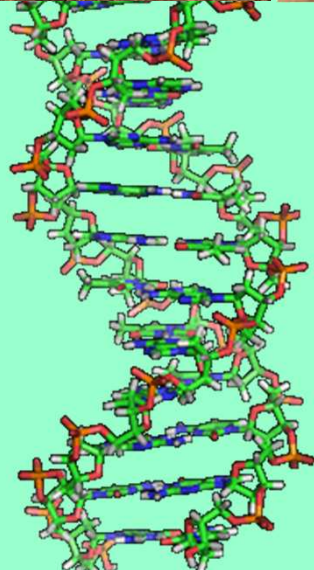
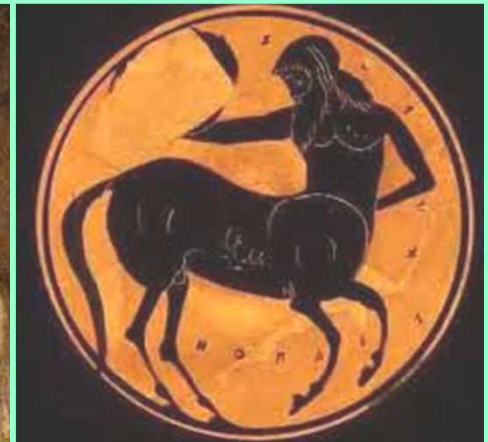
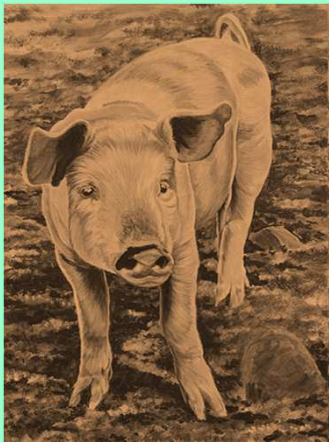


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