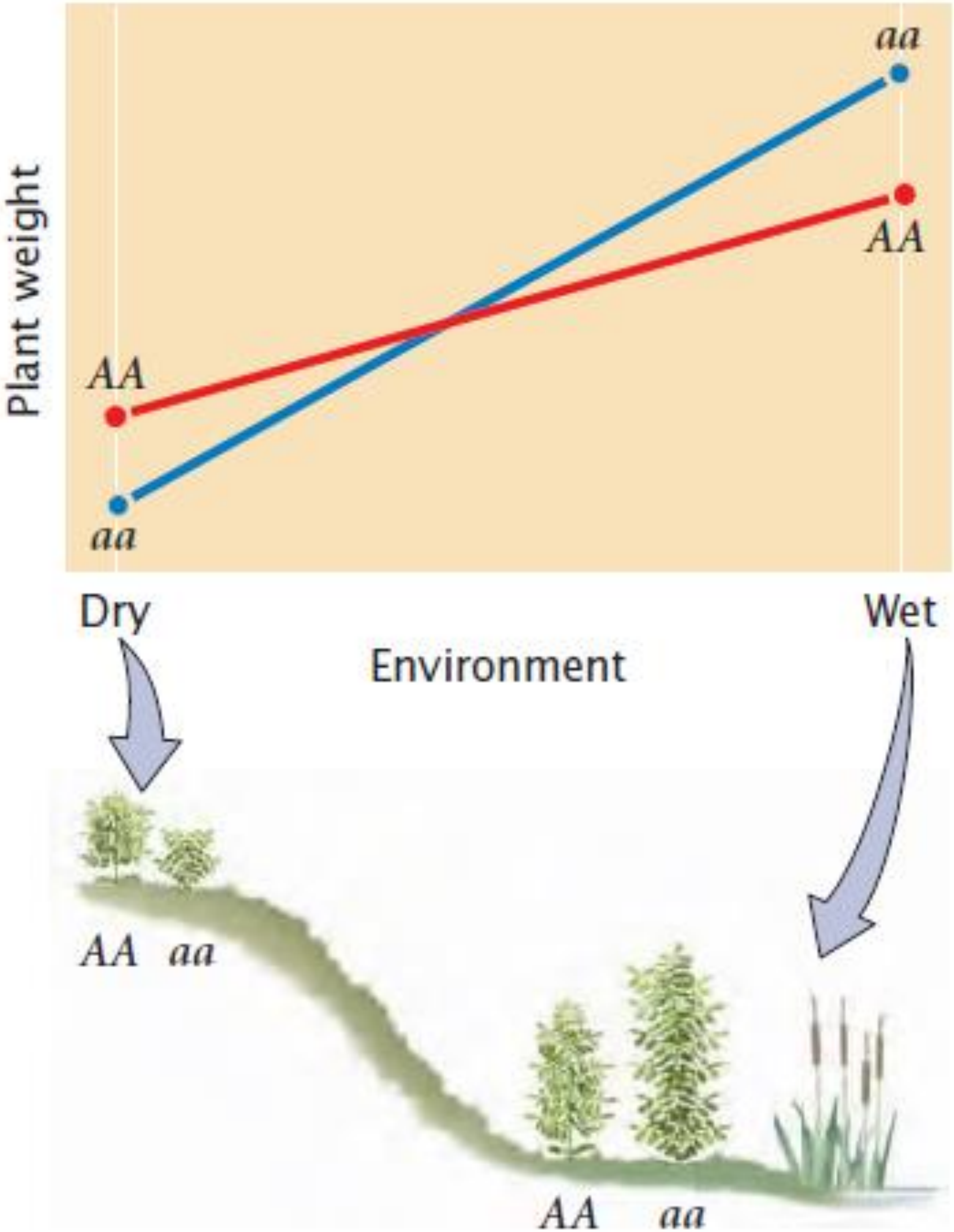
QTL

BIOS 0802

2017

Phenotype variance

- Lets think of an example where plant weight is considered
- If you measure many plants and club them together as V_P
- Some of the variation will be because of genetic variance V_G
- Some will be environmental variance V_E
- Some will e genetic-environmental variance V_{GE}
- Because at the end phenotype is accumulation of all the other facts; so
  - $V_P = V_G + V_E + V_{GE}$



Components of genetic variance

- Additive genetic variance = V_A
- Dominance genetic variance = V_D
- Genic interaction variance = V_I
- so the genetic variance would be
  - $V_G = V_A + V_D + V_I$
- Therefore the whole phenotypic variance will be
  - $V_P = V_A + V_D + V_I + V_E + V_{GE}$

Types of heritability

- Broad sense heritability: A value of 0 indicates that none of the phenotypic variance results from differences in genotype and all of the differences in phenotype result from environmental variation. A value of 1 indicates that all of the phenotypic variance results from differences in genotypes.

$$\text{broad-sense heritability} = H^2 = \frac{V_G}{V_P}$$

- Narrow sense heritability: often proportion of the phenotypic variance that results from the additive genetic variance because, as mentioned earlier, the additive genetic variance primarily determines the resemblance between parents and offspring.

$$\text{narrow-sense heritability} = h^2 = \frac{V_A}{V_P}$$

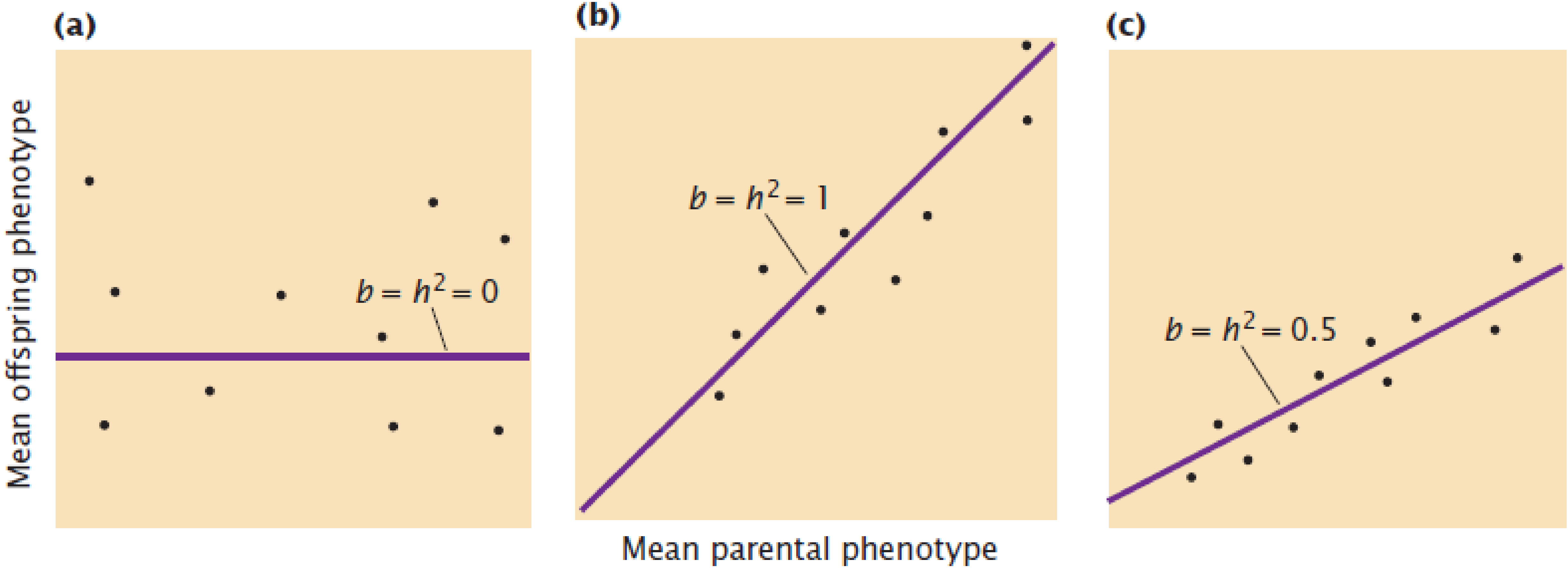
Calculating heritability

- Hard to control for all the environmental factors and therefore variance
- So we control for the genetic variance
  - If $V_G = 0$ (when all the plants are clone of one another)
  - Then $V_P = V_E$
- Then we can grow genetically variable plants and measure V_P
- Using V_E calculated on the genetically identical individuals, we could obtain the genetic variance of the variable individuals:
  - $V_{G\text{ (of genetically varying individuals)}} = V_{P\text{ (of genetically varying individuals)}} - V_{E\text{ (of genetically identical individuals)}}$
- Then the broad sense heritability:
  - $H^2 = V_{G\text{ (of genetically varying individuals)}} / V_{P\text{ (of genetically varying individuals)}}$

Example

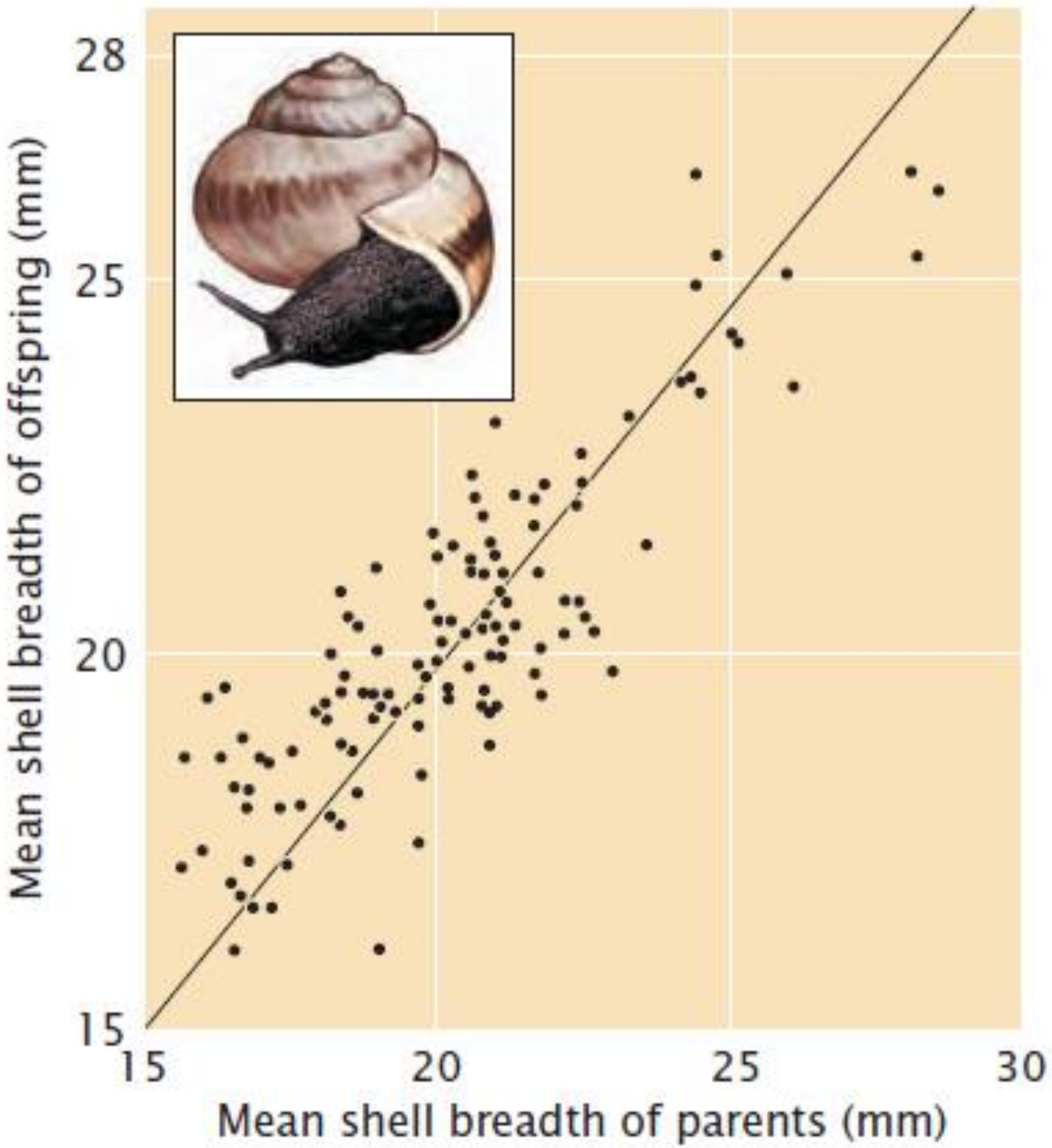
- Sewall Wright used this method to estimate the heritability of white spotting in guinea pigs.
- First he found that V_P = 573
- Then he inbred the guinea pigs until they are almost homozygous and found V_P = 340 (because in this population V_G=0 and therefore V_P=V_E)
- $V_P - V_E = V_G$ [573 − 340 = 233]
- $H^2 = V_G / V_P$ [0.41]
- This value implies that 41% of the variation in spotting of guinea pigs in Wright's population was due to differences in genotype.

Parent offspring regression



$$\text{narrow-sense heritability} = h^2 = \frac{V_A}{V_P}$$

Example


28
25
20
15
15
20
25
30
Mean shell breadth of offspring (mm)
Mean shell breadth of parents (mm)

Degrees of relatedness

- Monozygotic (identical) twins have 100% of their genes in common, whereas dizygotic (nonidentical) twins have, on average, 50% of their genes in common. If genes are important in determining variability in a characteristic, then monozygotic twins should be more similar in a particular characteristic than dizygotic twins. By using correlation to compare the phenotypes of monozygotic and dizygotic twins, we can estimate broad-sense heritability.

$$H^2 = 2(r_{MZ} - r_{DZ})$$

- where r_{MZ} equals the correlation coefficient among monozygotic twins and r_{DZ} equals the correlation coefficient among dizygotic twins. For example, suppose we found the correlation of height among the two members of monozygotic twin pairs (r_{MZ}) to be 0.9 and the correlation of height among the two members of dizygotic twins (r_{DZ}) to be 0.5. The broad sense heritability for height would be $H^2 = 2(0.9 - 0.5) = 2(0.4) = 0.8$.

Limitations

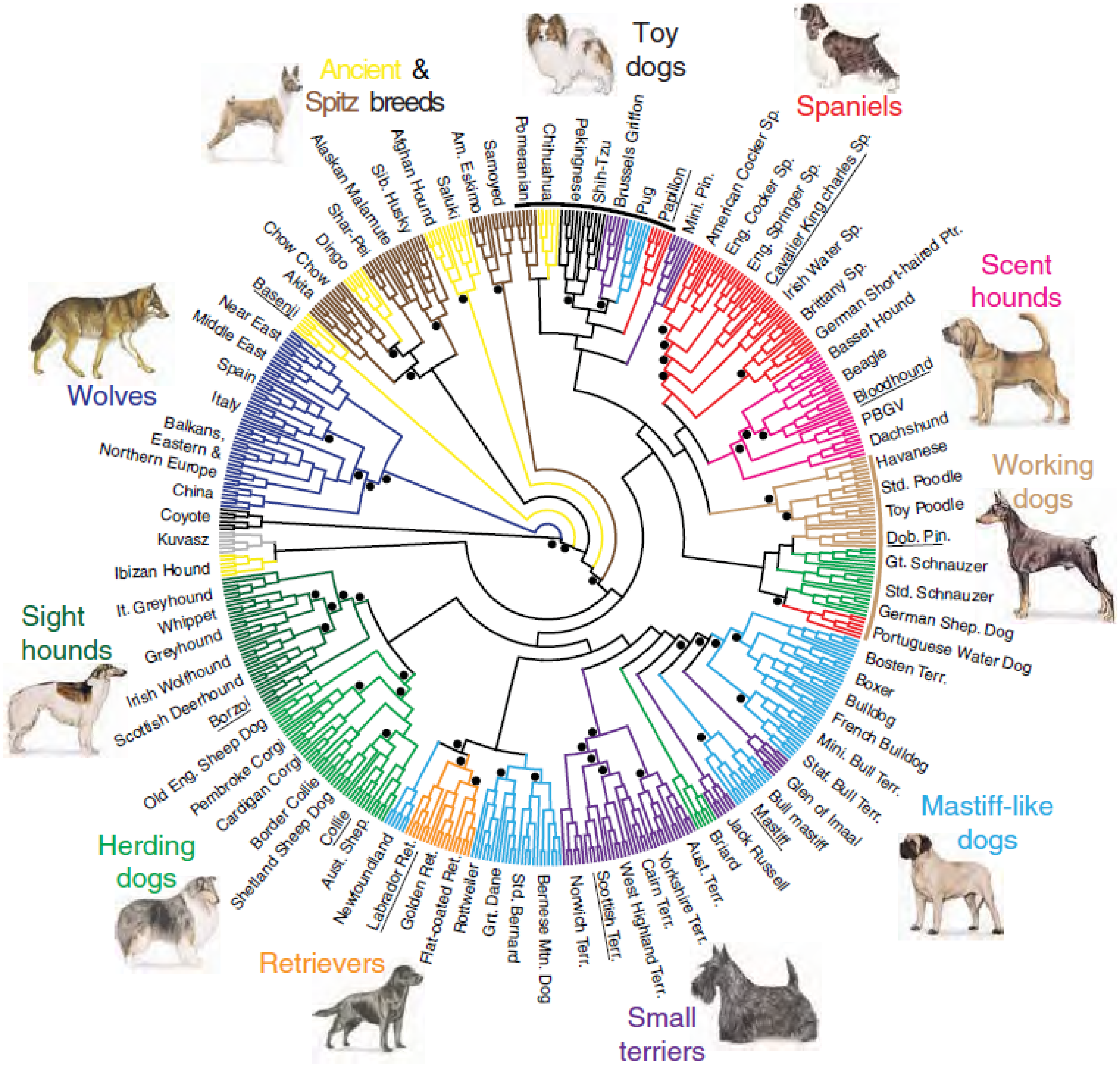
- Heritability does not indicate the degree to which a characteristic is genetically determined
- An individual does not have heritability
- There is no universal heritability for a characteristic
- Even when heritability is high, environmental factors may influence a characteristic
- Heritabilities indicate nothing about the nature of population differences in a characteristic

Examples of QTL

Table 24.2 Quantitative characteristics for which QTLs have been detected

Organism	Quantitative Characteristic	Number of QTLs Detected
Tomato	Soluble solids	7
	Fruit mass	13
	Fruit pH	9
	Growth	5
	Leaflet shape	9
	Height	9
Corn	Height	11
	Leaf length	7
	Tiller number	1
	Glume hardness	5
	Grain yield	18
	Number of ears	9
	Thermotolerance	6
Common bean	Number of nodules	4
Mung bean	Seed weight	4
Cow pea	Seed weight	2
Wheat	Preharvest sprout	4
Pig	Growth	2
	Length of small intestine	1
	Average back fat	1
	Abdominal fat	1
Mouse	Epilepsy	2
Rat	Hypertension	2

Dogs


Toy dogs
Ancient & Spitz breeds
Spaniels
Scent hounds
Working dogs
Mastiff-like dogs
Small terriers
Retrievers
Herding dogs
Sight hounds
Wolves
Alaskan Malamute
Sib. Husky
Afghan Hound
Saluki
Am. Eskimo
Samoyed
Pomeranian
Chihuahua
Pekingnese
Shih-Tzu
Brussels Griffon
Pug
Papillon
Mini. Pin.
American Cocker Sp.
Eng. Cocker Sp.
Eng. Springer Sp.
Cavalier King charles Sp.
Irish Water Sp.
Brittany Sp.
German Short-haired Ptr.
Basset Hound
Beagle
Bloodhound
PBGV
Dachshund
Havanese
Std. Poodle
Toy Poodle
Dob. Pin.
Gt. Schnauzer
Std. Schnauzer
German Shep. Dog
Portuguese Water Dog
Bosten Terr.
Boxer
Bulldog
French Bulldog
Mini. Bull Terr.
Staf. Bull Terr.
Glen of Imaal
Bull mastiff
Mastiff
Jack Russell
Briard
Aust. Terr.
Yorkshire Terr.
Cairn Terr.
West Highland Terr.
Scottish Terr.
Norwich Terr.
Bernese Mtn. Dog
Std. Bernard
Grt. Dane
Rottweiler
Flat-coated Ret.
Golden Ret.
Labrador Ret.
Newfoundland
Aust. Shep.
Collie
Shetland Sheep Dog
Border Collie
Cardigan Corgi
Pembroke Corgi
Old Eng. Sheep Dog
Borzoi
Scottish Deerhound
Irish Wolfhound
Greyhound
Whippet
It. Greyhound
Ibizan Hound
Kuvasz
Coyote
China
Balkans, Eastern & Northern Europe
Italy
Spain
Middle East
Near East
Basenji
Akita
Chow Chow
Dingo
Shar-Pei

Correlated responses

Table 24.3 Genetic correlations in various organisms

Organism	Characteristics	Genetic Correlation
Cattle	Milk yield and percentage of butterfat	0.38
Pig	Weight gain and back-fat thickness	0.13
	Weight gain and efficiency	0.69
Chicken	Body weight and egg weight	0.42
	Body weight and egg production	−0.17
	Egg weight and egg production	−0.31
Mouse	Body weight and tail length	0.29
Fruit fly	Abdominal bristle number and sternopleural bristle number	0.41

Pierce Genetics Chapter 24