1 # Traits of Complex Inheritance

2 ## Traits of Complex Inheritance

- **Multifactorial or Polygenic:** influenced by a large number of genes but also strongly influenced by the environment
  - **Genetic Component (polygenic)**
  - **Environmental Component** (nutritional status, sunlight, altitude, temperature, exposure to toxic waste, airborne pollutants, etc.; especially those that affect growth and development)
  - **Cultural Component**

3 ## Traits of Complex Inheritance

- The three components act together to produce a continuous distribution of phenotypes

4 ## Within Population Variation in Traits of Complex Inheritance

- Manifests itself in a typical Gaussian or "normal" distribution

5 ## Between Population Variation and Traits of Complex Inheritance

- Manifests itself as overlapping normal curves with varying degrees of separation dependant on the trait being investigated

6 ## Comparative Statistics and Traits of Complex Inheritance

- Polygenic traits lend themselves well to metric analyses (measurement rather than frequencies)
- Consequently, scientists studying traits of complex inheritance use statistics to compare different populations using these kinds of traits
- Summary statistics are used to characterize populations such as the mean (average) and standard deviation (a measure of within group variation)
- Comparative statistics include simple univariate tests (t-tests) and multivariate tests (Biodistance statistics – Mahalanobis D)

7 ## Degree of Genetic Control

- Ranges from small to large (environment and culture being the other major contributors)

- Can be addressed through **Heritability Estimates:** the proportion of variation of a trait that is due to the variation of genotypes

8 ## Estimating Heritability:

Monozygotic and Dizygotic Twin Studies

- **Monozygotic and Dizygotic Twin Studies:** offer a source of data for determining heritability:
  - **Monozygotic twins:** – identical genomes – genetic component – phenotypic differences due to environmental differences (studies typically focus on twins raised apart)
  - **Dizygotic twins:** – related genomes – due to both genetic and environmental differences

9 # Human Body Form Variability

10 # Human Body Form Variability

- The human body form varies over a wide range of size and shapes
- Considerable variation among populations living today
- One of the more "striking" forms and often used forms of human variability (after skin color)

11 # Anthropometry: The Study of Human Body Form

- **Anthropometry** – the physical measurement of human body form – born out of the need for scientific subjectivity in the quantification of human variability
- Anthropometry lent a sense of scientific certainty to the measurement of human variation over simplistic observations such as tall vs. short; light vs. dark; etc.
- Anthropometry established well-defined measuring points and measurements
- Included all aspects of body form (anthropometry), skeletal form (**osteometry**), dental form (**odontometry**)
- Skeletal and dental studies allow both a **synchronic** and **diachronic** perspective on human variation in body form

12 # Human Body Form Studies

- Humans differ for a wide variety of traits relating to growth and development, such as stature, weight, body proportions, and body composition
- Anthropologists are interested in documenting the range of variation for these and other dimensions and in understanding the role of genes, nutrition, disease, and climate producing differences between individuals and populations

13 # Human Form Studies

1
- Dermatoglyphics (Fingerprints) – Lab VII
- Body Size (Stature)
- Body Form
- Head Size and Form
- Face Form
- Body Weight

2
- Growth Rates
- Skin Color
- Eye Color
- Hair Color
- Hair Form

14 # Dermatoglyphics – Lab VII

- **Dermatoglyphics** are the numerous fine epidermal ridges found on the palmar surfaces of the hands and on the plantar surfaces of the foot
- These ridges form regular but complex patterns
- Found in other primates (including on the tails of New World monkeys with prehensile tails) besides humans are also found in some arboreal (tree living) marsupials
- Adaptation to living in the trees – the ridges and furrows give an increased surface of friction

15
Classification of Finger Patterns

- Most finger patterns can be classified into **arches**, **loops**, or **whorls** but there is great variation in individual detail
- No two people have identical fingerprints – not even monozygotic twins

16
Arches

- The simplest form of fingerprints with a parallel series of curved ridges passing transversely across the finger pad

17
Loops

- In loops, three adjacent lines meet to form a Y-shaped point known as the **triradius** or **delta** on either the ulnar (towards body when palm is held forward) or radial side (away from body)

18
Whorls

- In whorls, there are two such triradii or delta and the main lines which participate in them surround a central core

19
Other Fingerprint Variations

- Other variations can occur but are generally combinations of the three basic types of fingerprints
- Individuals can exhibit different types on their fingers

20
Ridge Count Method

- Along with the categorization of fingerprint patterns, the **ridge count method** is probably the most widely used for categorizing fingerprints
- The **ridge count** is defined as the number of ridges transecting a straight line drawn from the **core** (the innermost ridge of the pattern) to the **delta or triradius** (a point where three ridges diverge)

21
Total Ridge Count

- **Total Ridge Count** is the total number of ridges on all fingers
- Arches have no ridge count
- Loops have a single delta and hence a single line for a ridge count
- Whorls have two deltas, and therefore will have two lines drawn for ridge counts. Only one is added to the total ridge count

22
Genetics of Fingerprints

- About 90% of the pattern of fingerprints is inherited
- Most likely through a complex polygenic mode of inheritance
- Some chromosomal abnormalities result in changes to the dermal ridge patterns indicating that their genetic control lies on different chromosomes
- Monozygotic/Dizygotic twin studies indicate high heritability in the ridge count (MZ – 95% correlation; DZ – 60%)

23
Worldwide Variation

- Loops are the most common fingerprint pattern, followed by whorls, and then arches
- Arches show considerable variability

24 Body Size (Stature)

- **Stature (standing height)** is taken with an anthropometer which consists of a fixed vertical scale with a cross bar to be brought in contact with the top of the head – the subject standing erect with heels together and no shoes
- Can be taken on the living and can be estimated from skeletal material using long bone lengths and regression equations

25 Stature and Twin Studies

- Twin studies indicate that stature is under fairly strong genetic control

26 Worldwide Variation in Stature

- Ranges from 150 to well over 185 centimeters
- Tendency for shorter peoples near the equator and taller people further from the equator
- Numerous exceptions exist and there appears to be no real pattern
- May strongly relate to nutritional status

27 Stature and Sexual Dimorphism

- **Sexual dimorphism** (differences in form or size between males and females)
- Y-chromosome gene(s) influence a slower rate of maturation in males than females but eventually attain a larger overall size
- Males tend to be larger than females by 5 to 10 percent on average

28 Stature and Correlations with Other Human Form Measures

- Stature is highly correlated with other complex traits including trunk length, leg length, and head length

29 Body Form

- People vary not only in stature but also the relative contributions to stature of the legs and torso and head

30 Body Form

- **Cormic Index:** one measure of human body form, the ratio between sitting height and standing height (Sitting Height/Standing Height * 100)
- Gives an indication of the proportion of height that is made up by the torso and head (rather than the legs)
- A ratio of 50 indicates equal trunk and leg proportions, lower than 50 indicates long legs relative to trunk length and above 50 indicates short legs relative to trunk length

31 Worldwide Variation in the Cormic Index

- 45-50% in Australian aborigines and many African populations (long legs, short trunk)
- 53-54% in Asian populations including Chinese, Eskimos, and Native Americans (long trunk, short legs)
- These two extremes thought to relate to climate adaptations

32 Intermembral Index

- **Intermembral Index:** a relative measure of the upper (arm) and lower limbs (leg); ((humerus length + radius length)/(femur length + tibia length))
- Indicator of locomotory behavior in primates but also varies in human populations

33 Head Size and Form

- **Cephalic Index:** the ratio of head breadth to head length (cephalic length/cephalic breadth *100)
- Used in early studies as a classification method for understanding human variation
- Although continuous in its distribution it is common to divide that distribution into three categories:

- Dolichocephalic (below 75) – long, narrow head
- Mesocephalic (75-80) – medium head
- Brachycephalic (greater than 80) – broad head

34
Cephalic Index

- Only a crude measure of head shape when viewed from above (the horizontal plane)
- Inheritance studies on the character have yielded no clear results
- Modern populations are generally more brachycephalic than their predecessors (Kennewick Man)

35
Distribution of the Cephalic Index

36
Worldwide Distribution of Cephalic Index

- Beals et al.'s study of data for 20,000 skulls from around the world found a close association between environmental temperature and head shape
- Populations in colder climates had, on average, rounder heads than peoples in the tropics – a trait of adaptive significance
- **Beal's Rule** – the closer a structure approaches a spherical shape the lower the surface to volume ratio and hence the less heat loss through the head (80% of our body heat is lost through the head)
- Longer heads would allow dissipation of heat

37
Cranial Capacity

- Can be measured in both the living and the dead using measurements and formulae in the living and by direct measurement in the dead
- Three measures (cephalic length, breadth, and height) can be taken and used to calculate cranial capacity in the living
- In cranial material the cranial capacity can be measured directly through filling the brain cavity with different substances (shot, poppy seeds, mustard seed)

38
Evolution of Cranial Capacity

- Low average of 450 cc among our earliest ancestors (*Australopithecus*)
- Average of 650 cc in *Homo habilis*
- Average of 970 cc in *Homo erectus*
- Average of 1450 cc in Neandertals
- Average of 1345 cc in modern humans

39
Worldwide Variation in Cranial Capacity

- Wide range of variation in modern populations
- Some overlap with fossil species
- Cranial capacity correlated with stature – larger brains are associated with larger overall body size
- Highly variable within a population

40
Face Form

- Human face is highly variable in shape and form
- Human face is a morphological complex revolving around three structures (eyes, nose, and mouth)
- **Facial Index:** a ratio of face length to face breadth (Face Length/Face Breadth * 100) – broad short faces vs. long narrow faces
- Flat, broad faces of Asians has been associated with an adaptation to cold climates

41 Face Form and Prognathism

- **Prognathism:** forward projection of the dental arches
- Large degree of facial prognathism in humans due to the presence of large teeth
- Less prognathism is associated with a reduction in tooth size and the invention of cooking vessels

42 Nose Form

- Nose dominates the mid-facial region
- Form and size vary over a wide range but can be quantified through a couple of measures and the use of a shape index:
- **Nasal Index:** ratio of the nasal breadth to the nasal length (Nasal Breadth/Nasal Length * 100)
- Ranges from 64 to 100%

43 Worldwide Variation in Nasal Form

- Ranges from 64 to 100%
- Short broad noses (above 100) are found in central Africans, Australian Aborigines
- Long narrow noses (less than 85) are found in Native Americans, North Africans, Europeans, and Eskimos

44 Nose Form and Selection

- Nose functions to warm, filter, and moisten the inspired air and hence the shape of the nose is thought to be the result of selection for these features in different climates:
  - Narrow nose provides a more efficient mechanism for warming and moistening the inspired air and can warm air to a greater extent and provides greater internal surface area – found colder and drier climates
  - Short broad nose is more common in warmer and humid areas

45 Body Weight

- Body weight varies over a wide range as does body size and shape
- Adults vary from 32 kg (70 lbs) to more than 90 kg (200 lbs)
- Weight does not correlate well with body size (stature)
- **Body Mass Index** = Weight/Stature^2

46 BMI and Selection

- A close correlation with mean annual temperature – in colder areas people are much heavier relative to their height than in warmer regions

47 Bergmann’s Rule

- Carl Bergmann was a German physiologist who noted a relationship between body-size relative to mean annual temperature
- Populations inhabiting the warmer regions were smaller and lighter and in colder regions they were larger and heavier
- Noted that 70% of the body’s metabolic heat is lost through radiation, therefore surface area to weight ratio was an important aspect of body shape
- Carl Bergman proposed that body size was simply a matter of energy conservation in colder areas and a matter of heat dissipation in warmer areas

48 Bergmann's Rule

- Borrowing from **Fourier's Law of Heat Flow** (heat lost per minute is directly proportional to body surface and the difference between core temperature and ambient temperature) Bergmann proposed his rule governing animal body sizes
- **Bergmann's Rule:** Among mammals of similar shape, the large mammal loses heat less rapidly than the small mammal and among mammals of similar size, the mammal with a linear shape will lose heat more rapidly than the mammal with a non-linear shape

49 Bergmann's Rule

1 - Among mammals of similar shape, the large mammal loses heat less rapidly than the small mammal
2 - Among mammals of similar size, the mammal with a linear shape will lose heat more rapidly than the mammal with a non-linear shape

50 Non-Human Example of Bergmann's Rule:

51 Human Example of Bergmann's Rule

52 Allen's Rule

- John Allen, zoologist who applied Bergmann's rule to body limbs and predicted that mammals in cold climates should have shorter, bulkier limbs, whereas mammals in hot climates should have longer, narrower ones.
- Analyses of many different populations have found that Bergmann's and Allen's Rules are accurate in describing trends among human populations in the world today as well as in the past

53 Other Human Body Form Topics to Consider

- Growth and Development
  - Growth Rates
    - Skeletal Maturation
    - Skull
    - Dental Maturation
    - Sexual Maturation
  - Longitudinal Growth Trends
  - Environmental Influences and Ethnic Differences
- Structure and Function of Skin, Skin Color
- Eye Color
- Hair Color
- Hair Form