Concepts and Categories

Lecture 21

Learning, Perception, and Memory Rely on Thinking

- Learning
  - Classical Conditioning
    - How can I predict some event?
  - Instrumental Conditioning
    - How can I control that event?
- Perception
  - What is out there? Where is it? What is it doing?
- Memory
  - What happened in the past?

"Every act of perception is an act of categorization"

Bruner (1957) [paraphrase]

- Fundamental Cognitive Process
  - Perceptual Identification...
    - Of Individual Object
  - Categorization...
    - As Belonging in Same Class as Other Objects

- Categorical Knowledge is Part of Semantic Memory
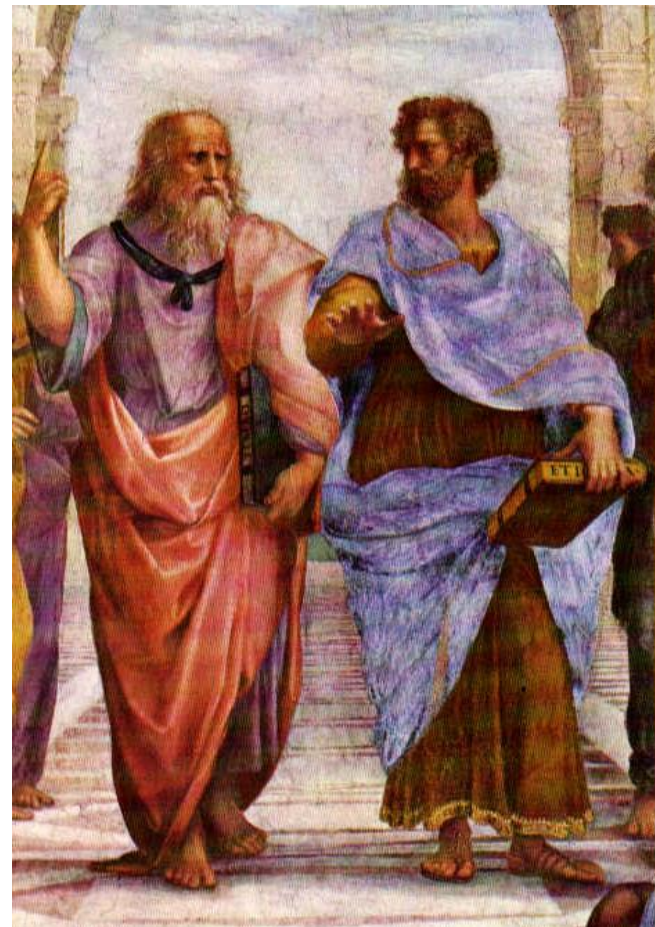
Categories and Concepts

- Enumeration
- Rule
- Attributes
  - Perceptual
  - Functional
  - Relational

Classical View of Categorization

Aristotle, *Categories* (in the *Organon*, 4th C. BCE)

Categories are Proper Sets

- Defining Features
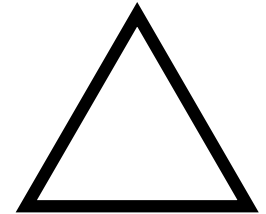 - Singly Necessary
  - Jointly Sufficient

Defining Features
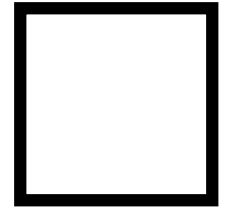
- Geometrical Figures
  - Triangles
    - 2 Dimensions, 3 Sides, and 3 Angles
  - Quadrilaterals
    - 2 Dimensions, 4 Sides, and 4 Angles
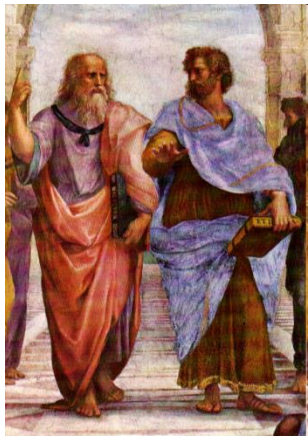- Animals
  - Birds
    - Vertebrate, Warm-Blooded, Feathers, Wings
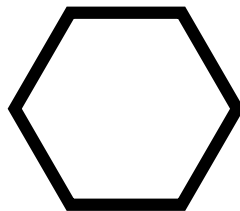 - Fish
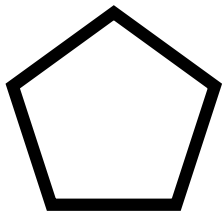   - Vertebrate, Cold-Blooded, Scales, Fins

Categories as Proper Sets

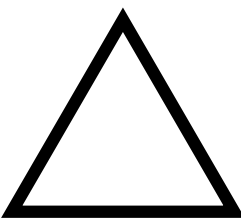Aristotle, *On Categories*, etc.

- Defining Features
- Vertical Arrangement into Hierarchies
  - Perfect Nesting
    - Superordinate (Supersets)
    - Subordinate (Subsets)

Geometric Figures
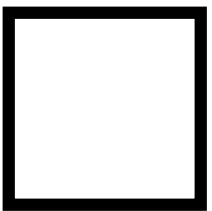
Subcategories of Triangles

- Classified by Length of Sides
  - Equilateral
  - Isosceles
  - Scalene
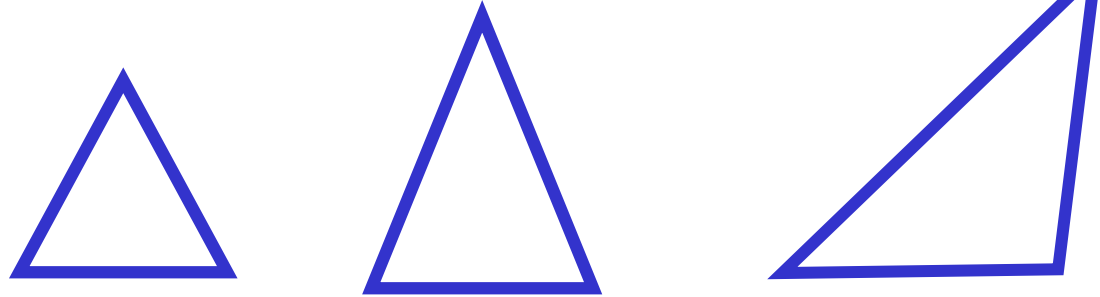
- Classified by Internal Angles
  - Right
  - Oblique
    - Obtuse
    - Acute
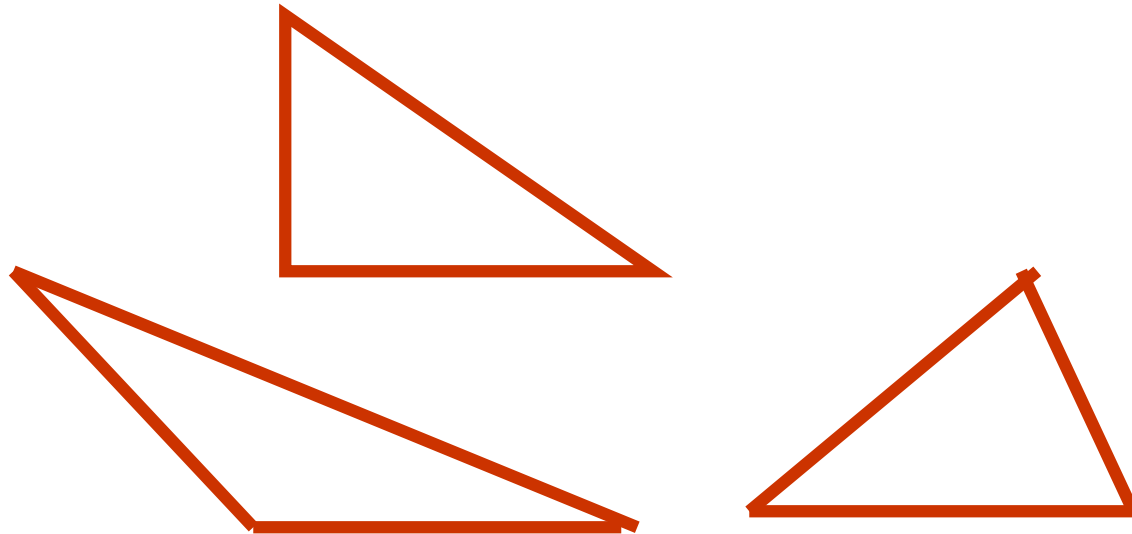
Subcategories of Quadrilaterals

- Trapeziums

- Trapezoids
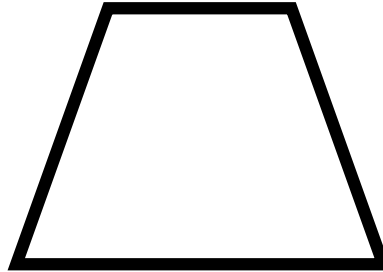
- Parallelograms
  - Rhomboids
    - Rhombuses
  - Rectangles
    - Squares

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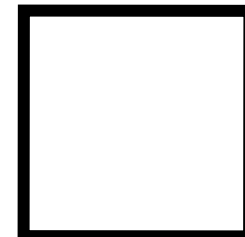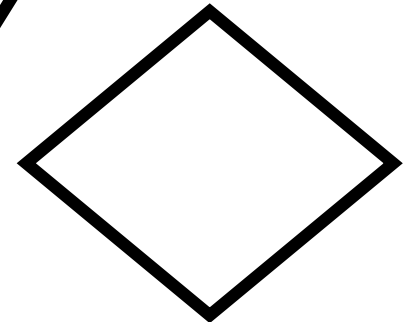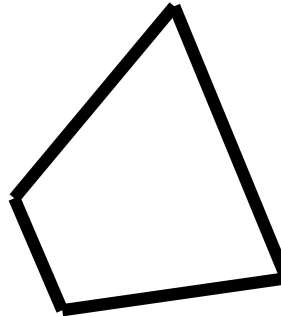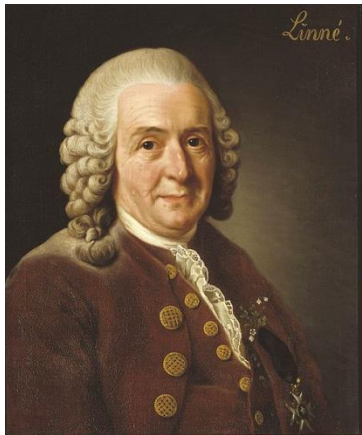
Biological Taxonomy
Linnaeus (1758)
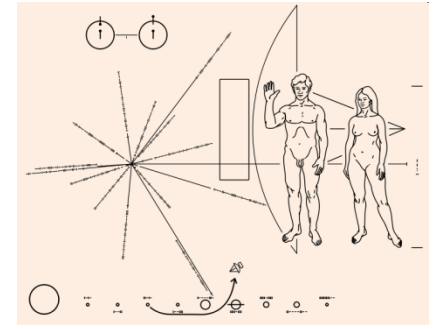
Pioneer 10

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species
- Subspecies

- Animalia
- Chordata
- Mammalia
- Primates
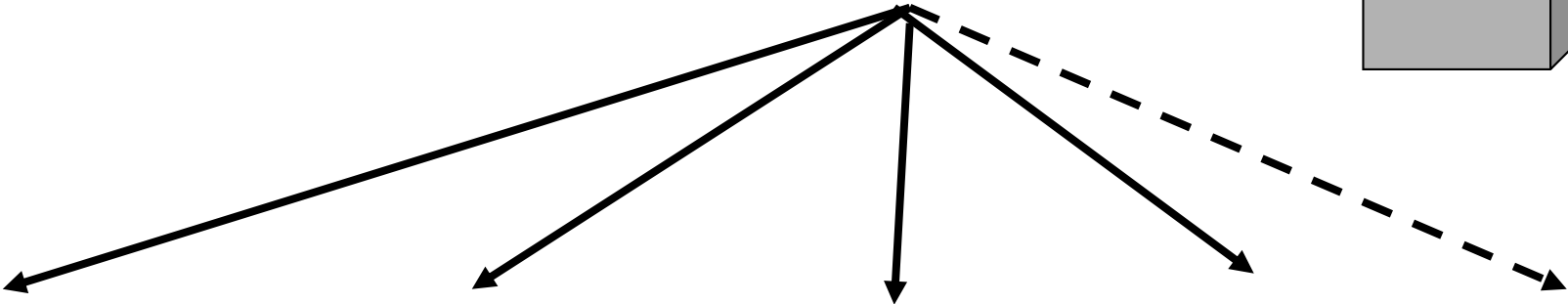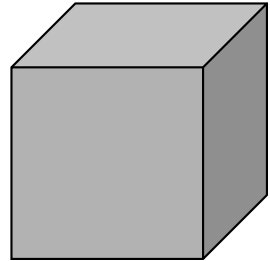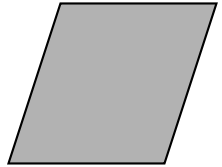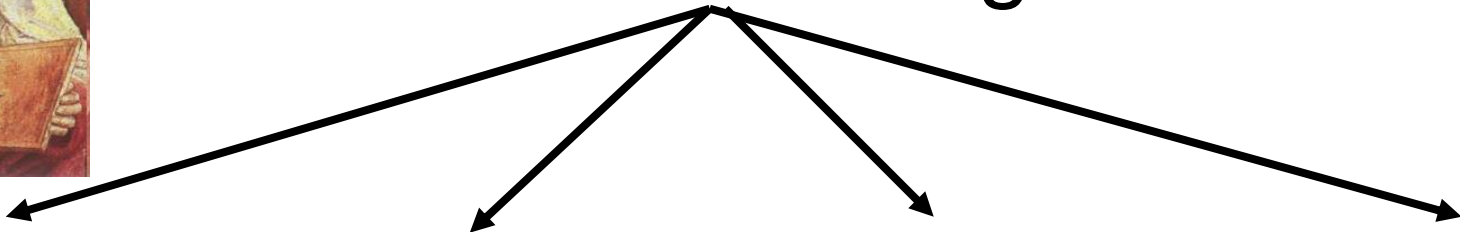- Hominidae
- Homo
- Sapiens
- Sapiens
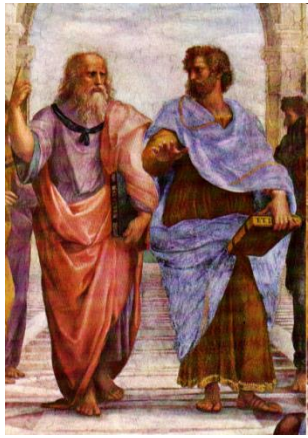
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Categories as Proper Sets
Aristotle, *On Categories*, etc.

- Defining Features
- Vertical Arrangement into Hierarchies
- Horizontal Relations
  - "All or None"
  - Sharp Boundaries

Geometrical Figures
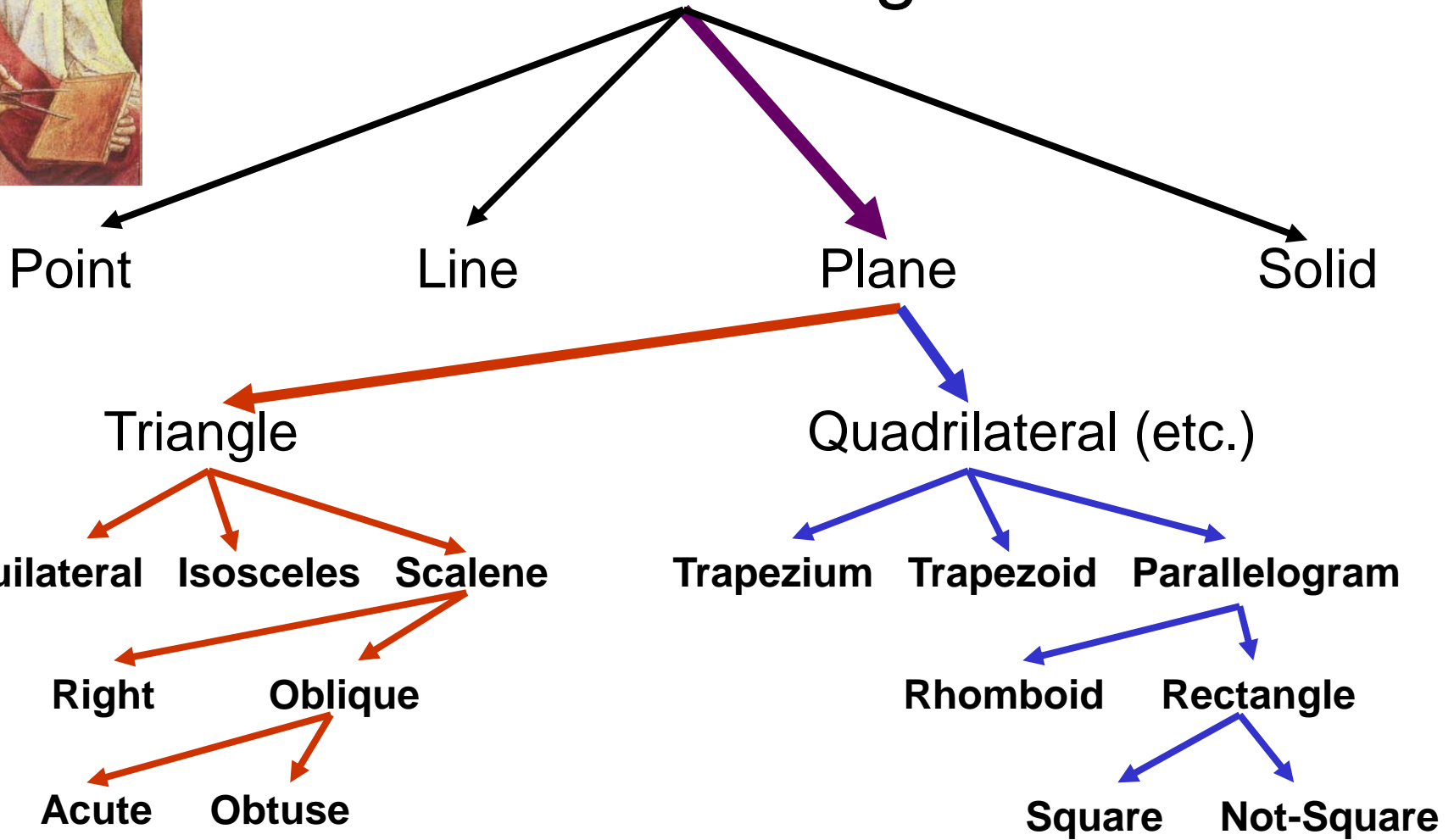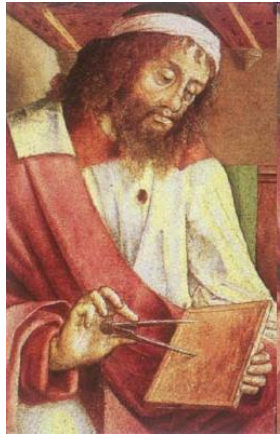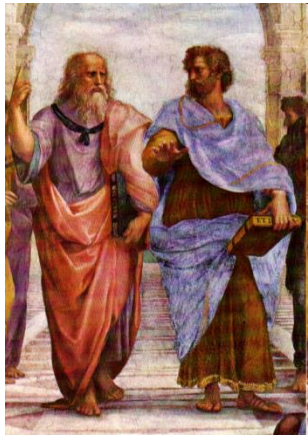
Point　　　　Line　　　　Plane　　　　Solid

Triangle　　　　　　　Quadrilateral (etc.)

Equilateral　**Isosceles**　**Scalene**　　**Trapezium**　**Trapezoid**　**Parallelogram**

Right　　**Oblique**　　　　**Rhomboid**　**Rectangle**

Acute　**Obtuse**　　　　　**Square**　**Not-Square**

Categories as Proper Sets

Aristotle, *On Categories*, etc.

- Defining Features
- Vertical Arrangement into Hierarchies
- Horizontal Relations "All or None"
- Homogeneous Internal Structure
  - All Instances Are Equally Good
    - All Share Same Set of Defining Features

Quadrilaterals

Wikipedia

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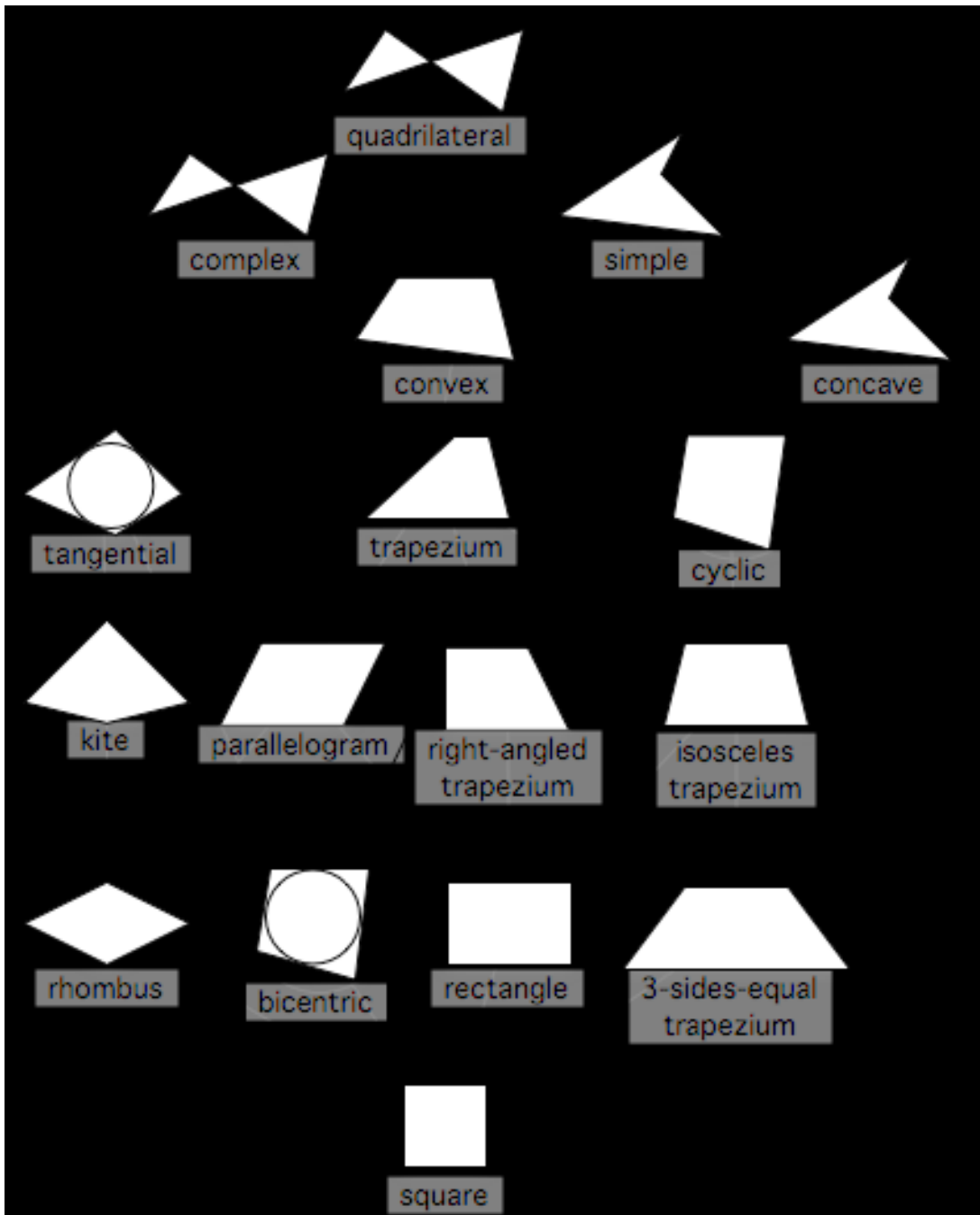
Algorithms for Categorization

- Defining a Category
  - Determine Defining Features
    - Shared by All Members
- Categorize an Object
  - Analyze Features of Object
    - Perception
  - Retrieve Defining Features of Category
    - Memory
  - Match Object Features to Defining Features
    - If Match, Assign Object to Category

Problems with Classical View of Categories as Proper Sets

- **Disjunctive Categories**
  - Baseball Strike
    - Swing and Miss
    - Pitch in Strike Zone
    - Foul Ball
    - Called Strike
  - Jazz
    - Blues
    - Swing (Standards)

Problems with Classical View of Categories as Proper Sets

- Disjunctive Categories
- Unclear Category Membership
  - Is a Rug an Article of Furniture?
  - Is a Pickle a Vegetable?

Is a Tomato a Fruit or a Vegetable?
Nix v. Hedden (1893)

- Tariff Act of 1883
  - Duty on Vegetables "In Natural State"
  - No Duty on Fruits
- Customs Collector for Port of New York
  - Declared Tomatoes to be Vegetables
- International Tomato Cartel
  - Sued, Took Case to US Supreme Court
- Justice Gray, for a Unanimous Court

Problems with Classical View of Categories as Proper Sets

- Disjunctive Categories
- Unclear Category Membership
- Difficult to Specify Defining Features
  – Required to Define Category
  – Required to Assign Category Membership

Eyes of Santa Clara

The Concept of *GAME*

(Wittgenstein (1953)

Problems with Classical View of Categories as Proper Sets

- Disjunctive Categories
- Unclear Category Membership
- Difficult to Specify Defining Features
- Imperfect Nesting
  - "Tangled Hierarchy"

Category Verification

Smith, Shoben, & Rips (1973)
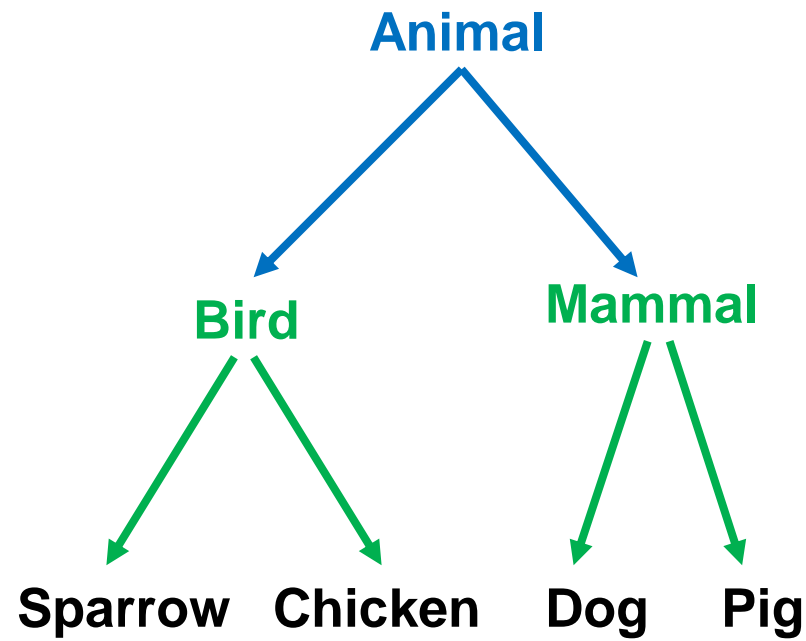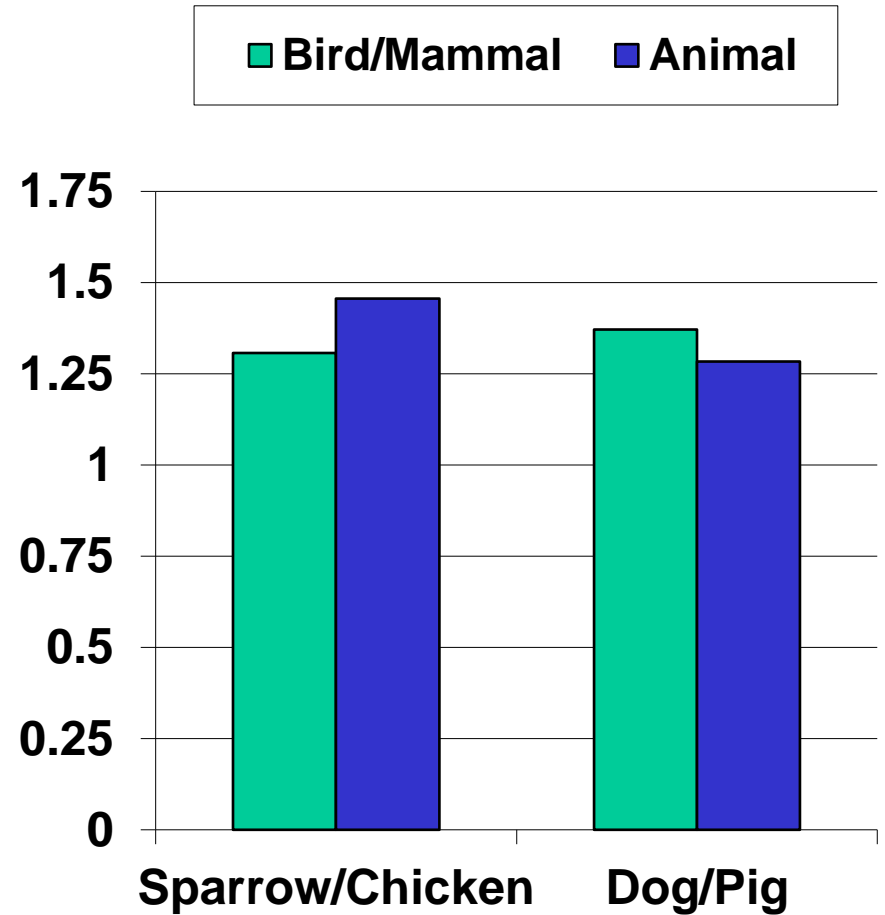
Problems with Classical View of Categories as Proper Sets

- Disjunctive Categories
- Unclear Category Membership
- Difficult to Specify Defining Features
- Imperfect Nesting
- Variations in Typicality
    - Birds: Sparrow vs. Chicken

"Typicality" Ratings

Rosch (1975)

- **Furniture**

  Chair, 1.10

  Desk, 1.54

  Rug, 5.0

  Ashtray, 6.35

- **Vegetable**

  Pea, 1.07

  Corn, 1.55

  Tomato, 2.23

  Pickle, 4.57

- **Fruit**

  Orange, 1.07

  Cherry, 1.82

  Pickle, 4.57

  Tomato, 5.58

- **Bird**

  Sparrow, 1.18

  Owl, 2.96

  Chicken, 4.02

  Penguin, 4.53

"Typicality" Ratings
Armstrong, Gleitman, & Gleitman (1983)

- **Even Number**
  - 4,   1.1
  - 10,   1.7
  - 18,   2.6
  - 106, 3.9
- **Odd Number**
  - 3,   1.6
  - 23,   2.4
  - 501, 3.5
  - 447, 3.7

- **Female**
  - Mother,   1.7
  - Housewife,   2.4
  - Princess,   3.0
  - Policewoman, 3.9
- **Plane Geometry Figure**
  - Square,   1.3
  - Rectangle,   1.9
  - Circle,   2.1
  - Ellipse,   3.4

Typicality Effects in Categorization
Smith, Rips, & Shoben (1974)
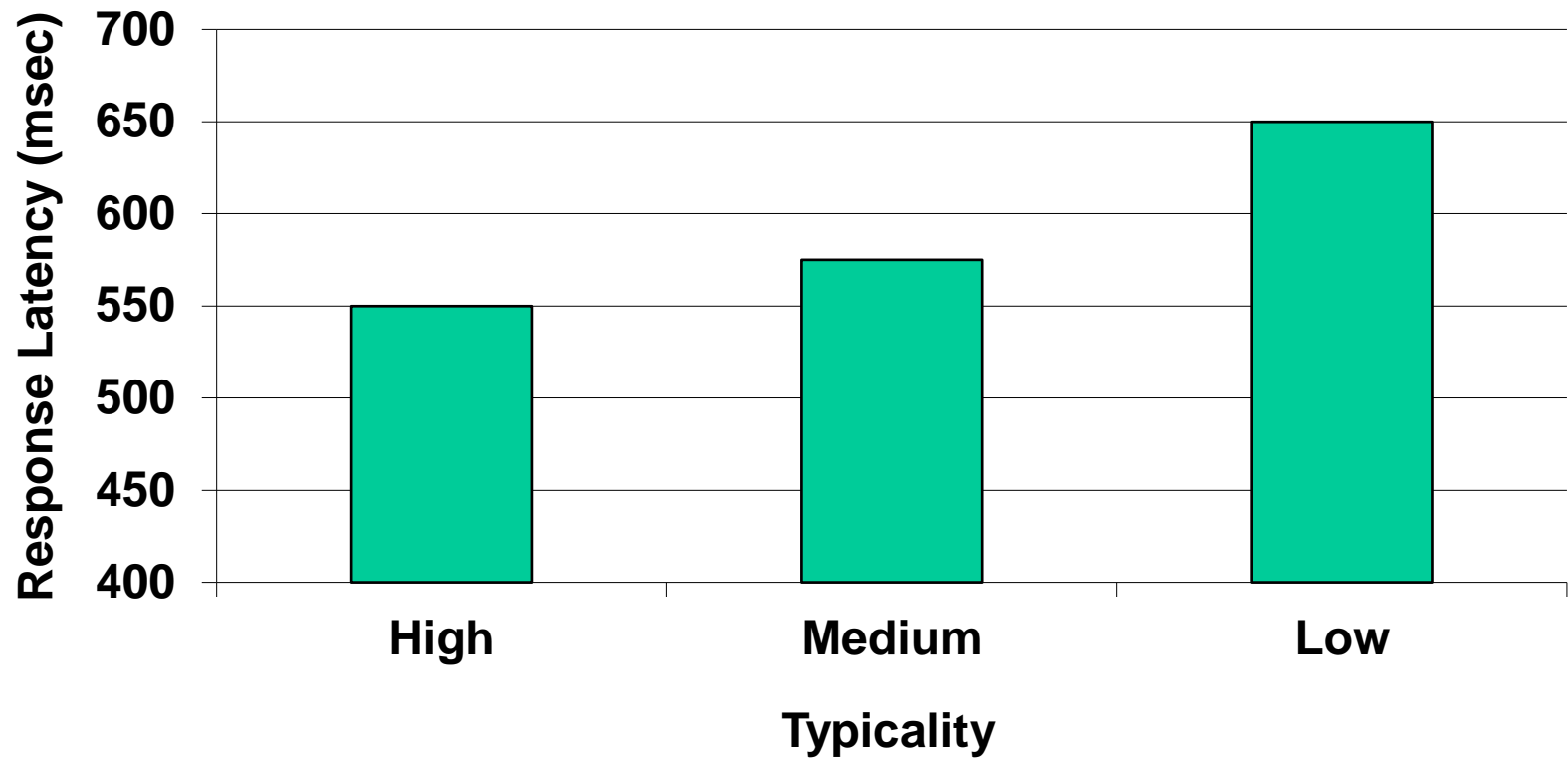
Implications of Problems with Classical View of Categories

- These problems would not occur if categories were represented as proper sets

- Therefore, people must do something else when they induce concepts or deduce category membership

- Apparently, concepts are not structured like proper sets after all!

"Prototype" View: Categories as Fuzzy Sets

Rosch (1975)

- No Defining Features
  - Probabilistic Relationship
    - Central vs. Peripheral
- Family Resemblance
- Category Based on Similarity to Prototype
  - Many Features Central to Category Membership
  - Few Features Central to Membership in Contrasting Categories
- Permits Heterogeneity Within Category
  - Typicality Effects

Problems with the Classical View of Categories Solved by the Prototype View

Rosch & Mervis (1975); Rosch et al. (1976)

- Disjunctive Categories

- Unclear Category Membership

- Difficult to Specify Defining Features

- Imperfect Nesting

- Variations in Typicality

Alternative "Exemplar" View
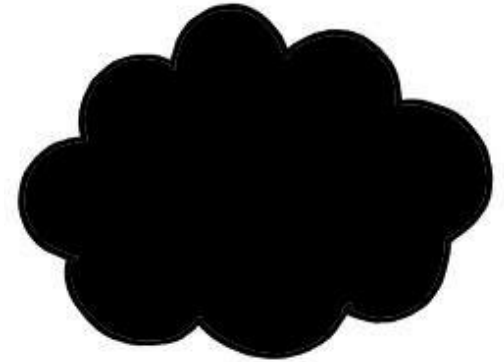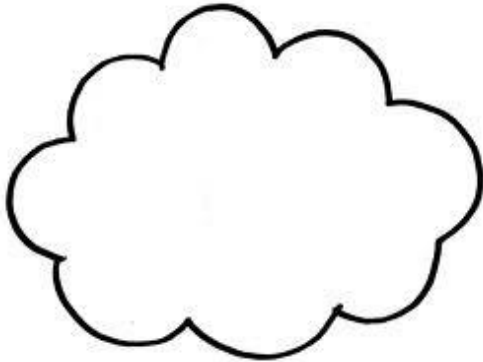### Medin & Schaffer (1978)

- Abandons Features
  - No Defining or Characteristic Features
- Concept as List of Members
  - Salient Examples of Category
- Compare Object to List of Exemplars
  - Categorization Still Based on Similarity
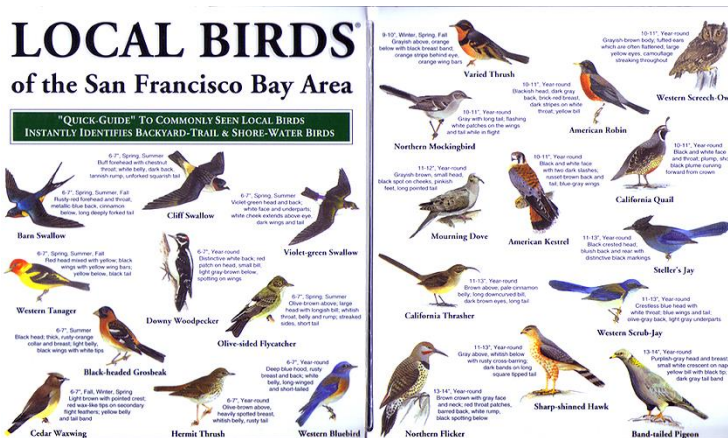
Problems with Similarity
After Medin & Shoben (1988); see also Medin et al. (1993)

The Theory (Knowledge-Based) View
Murphy & Medin (1985); Murphy (2002)

Concept : Instance :: Theory : Data

- Instances Not Bound Together by Similarity
  - At Very Least, "Similarity" is Flexible
  - Categorization Explains Similarity Judgments
- Concepts Organized by Theory of Domain
  - "Explanatory Relationship" Between Concept, Instance
- Categorization Based on Knowledge, Not Similarity

Implications of Categorization

- **Logically**, Categories are Structured as Proper Sets
  - Represented by Defining Features
- *Psychologically*, Categories are Structured as "Fuzzy" Sets
  - Represented by Prototypes, Exemplars
  - Representations Differ by Expertise
- Principles of Reasoning Do Not Necessarily Follow the Principles of Formal Logic
  - Cannot be Discovered by Reason Alone