Drawing in 3D

CSCI 4229/5229
Computer Graphics
Fall 2006

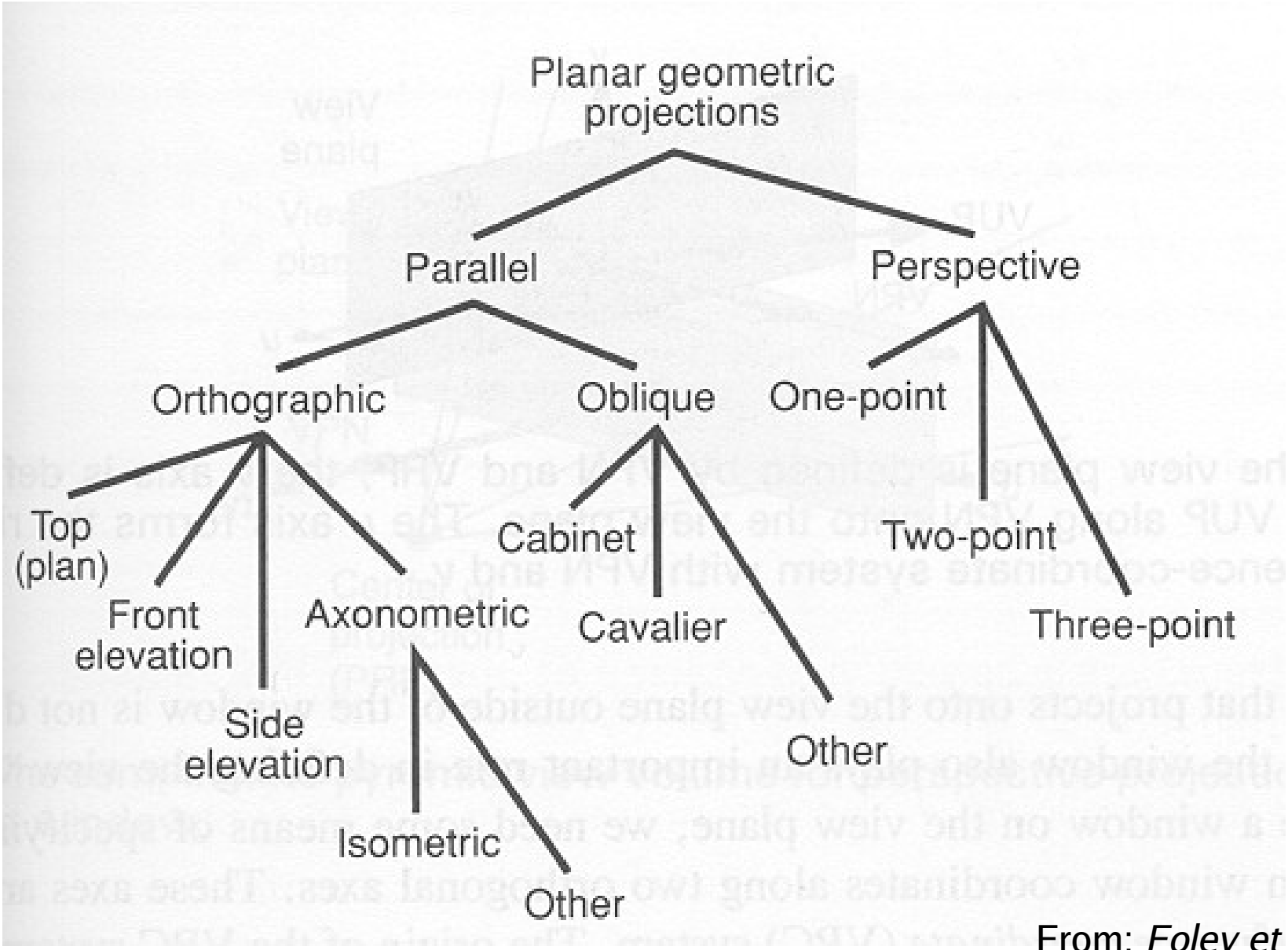
Differences from 2D

- The third dimension (duh!)
- Depth perception
- Hidden lines and surfaces
- Realism
  - Lighting
  - Shading
  - Texture

Types of Projections

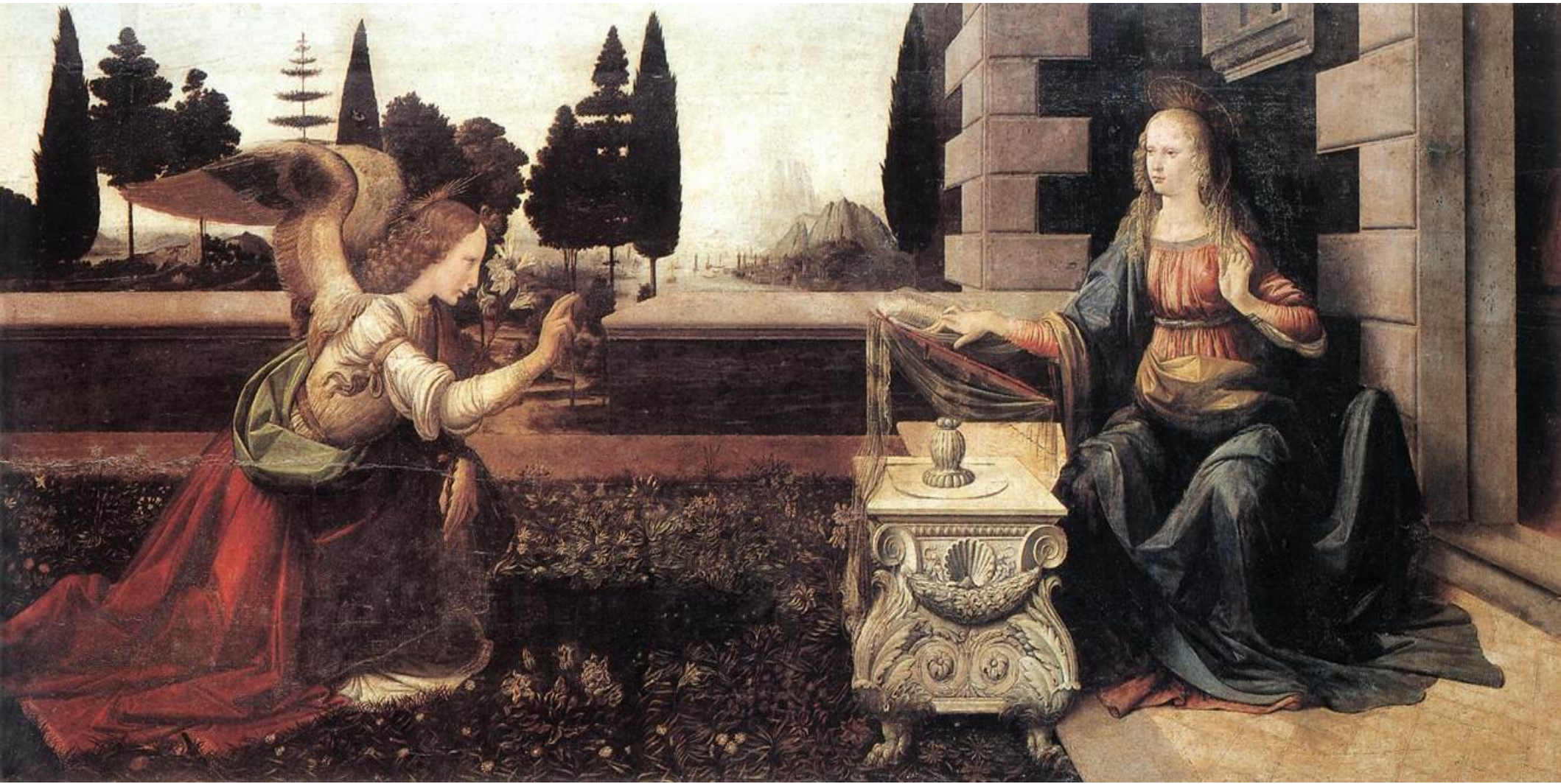
- Parallel Projections
  - Orthogonal, isometric, ...
  - Size does not diminish with distance
- Perspective
  - Realistic based on an observer's point of view
  - Nearer bigger, further smaller
  - One or more vanishing points

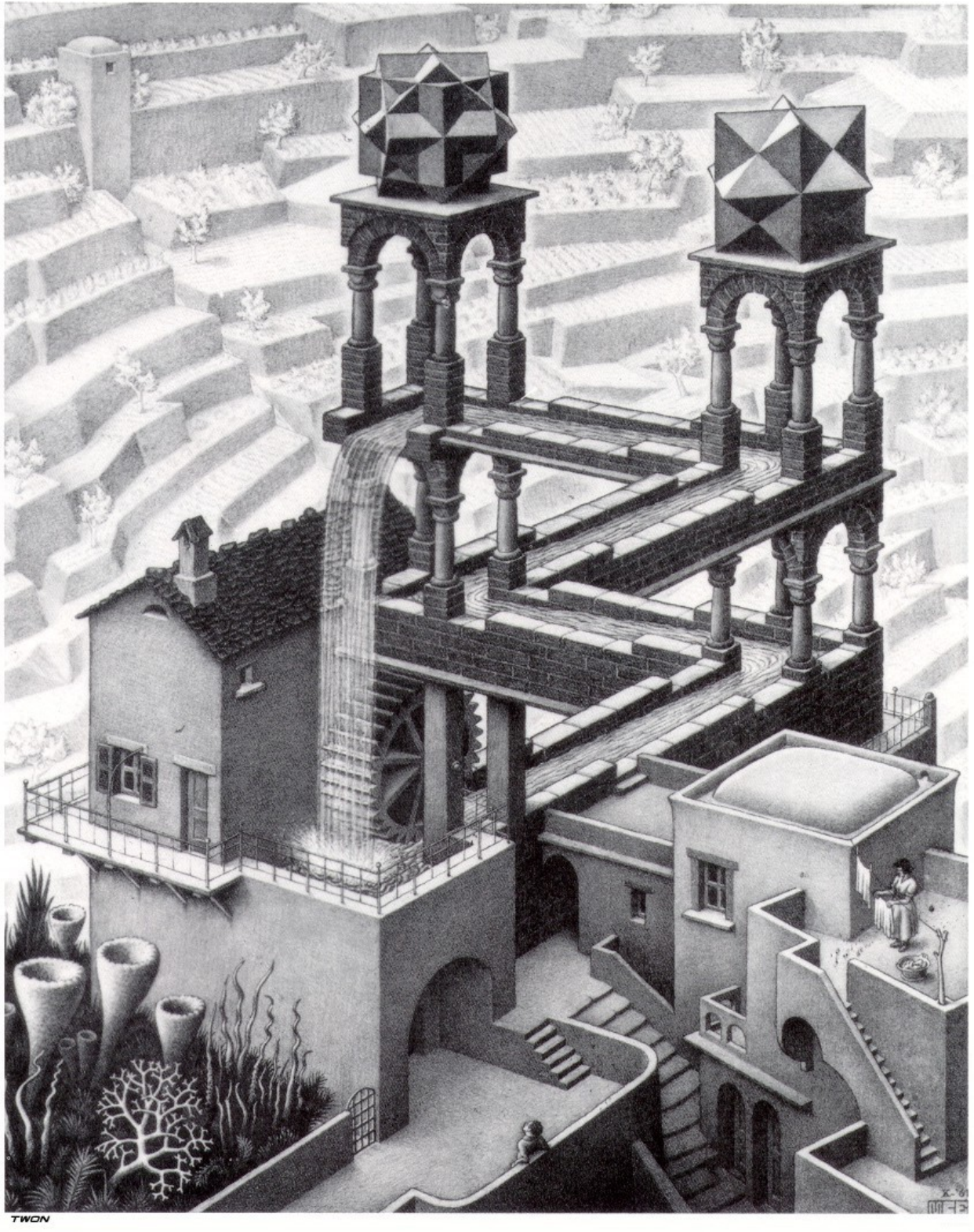
Taxonomy of Projections



From: *Foley et al*

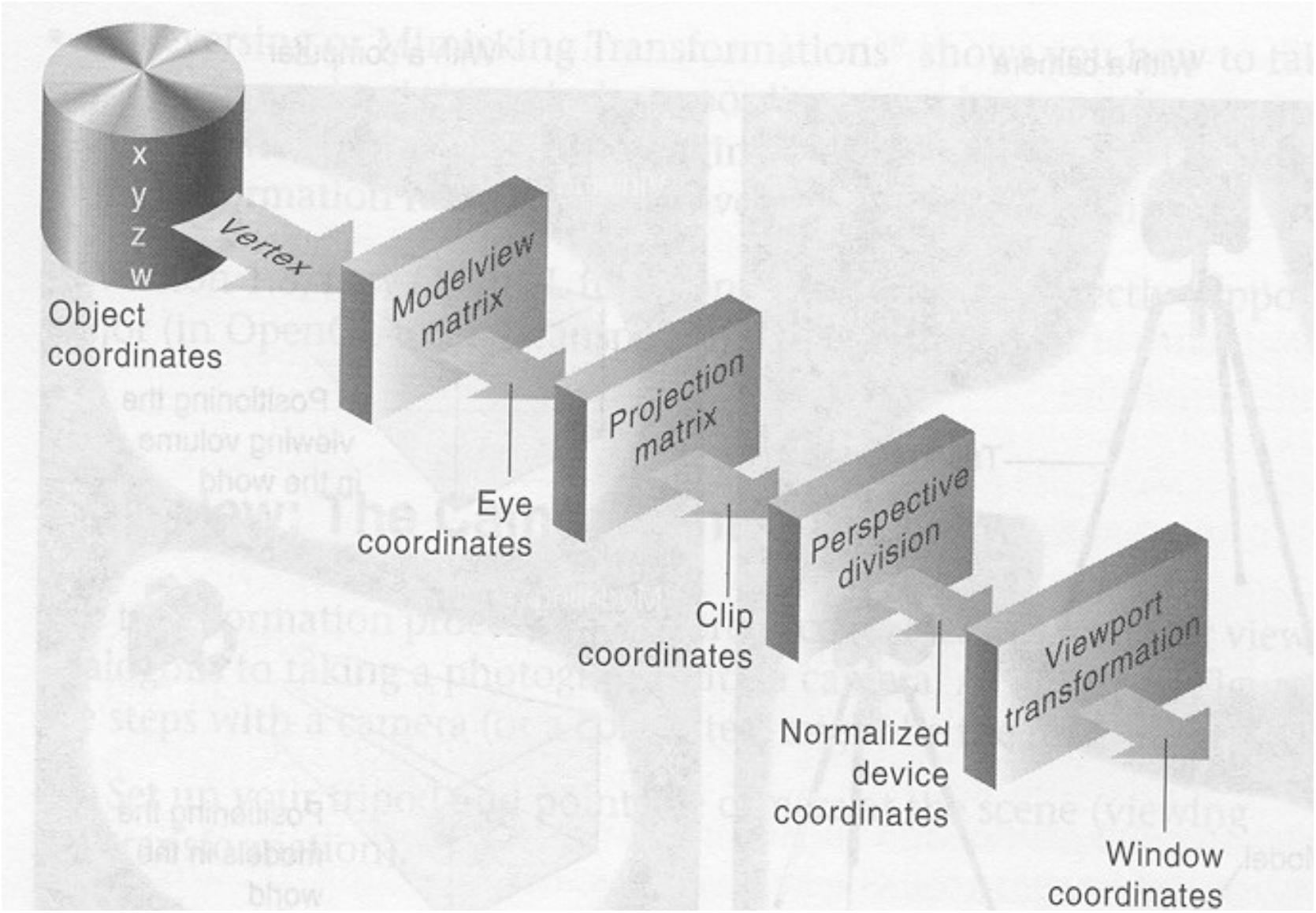
Annunciation
Leonardo da Vinci (1472)





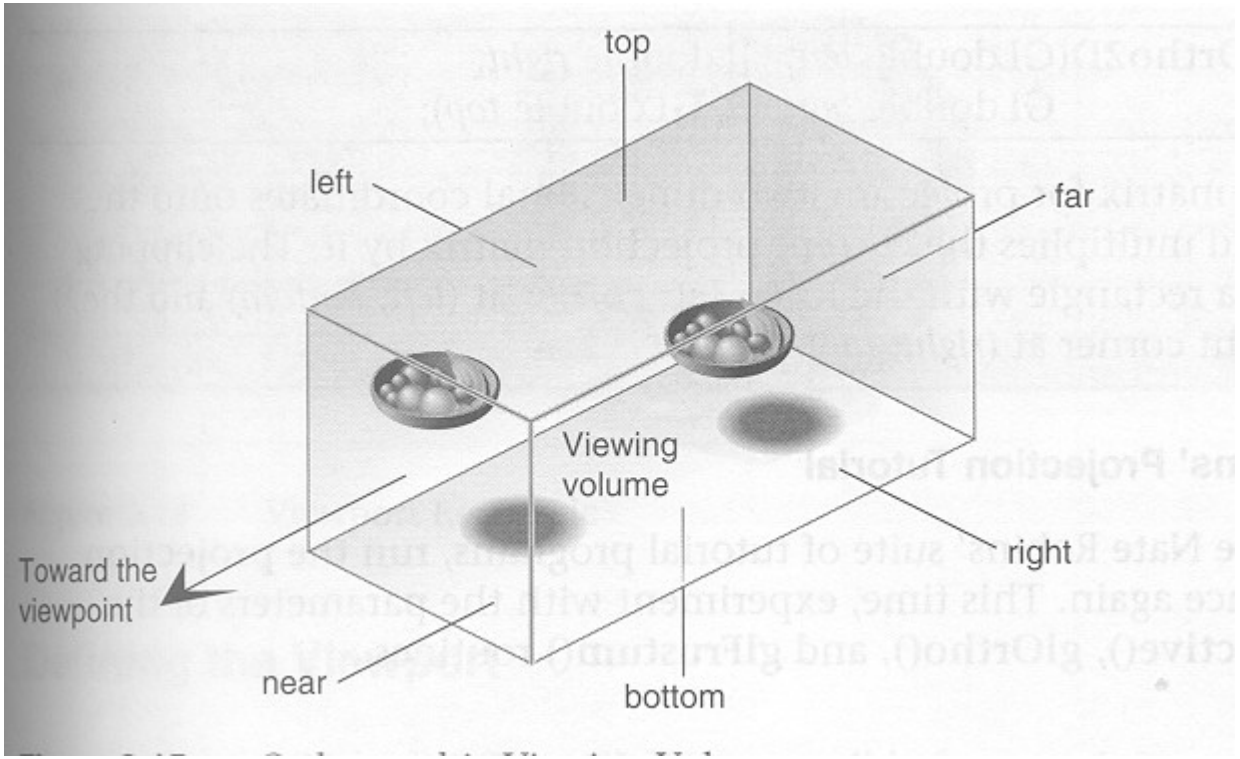
Waterfall
M.C. Escher
(1961)

OpenGL Transformation Pipeline



Parallel Projection

- Apply rotation matrix to map direction of projection to *Z* axis and up to *Y* axis
- Scale to canonical volume



From: *OpenGL Red Book*

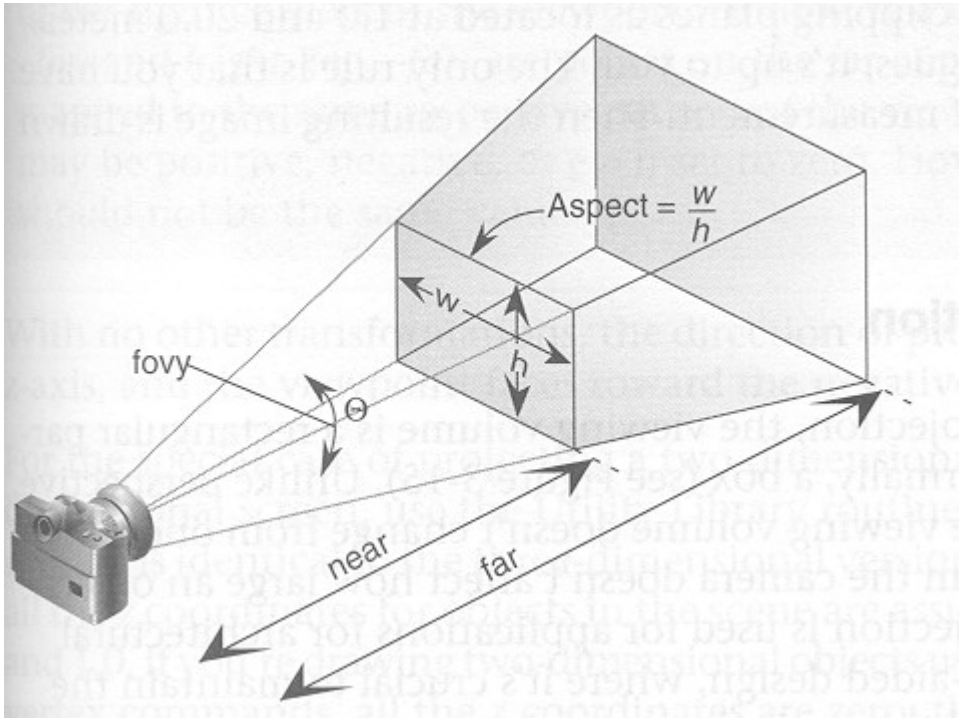
glOrtho(x_{min},x_{max},y_{min},y_{max},z_{min},z_{max})

glOrtho Projection Matrix

$$\begin{pmatrix} \frac{2}{x_{max}-x_{min}} & 0 & 0 & \frac{x_{max}+x_{min}}{x_{max}-x_{min}} \\ 0 & \frac{2}{y_{max}-y_{min}} & 0 & \frac{y_{max}+y_{min}}{y_{max}-y_{min}} \\ 0 & 0 & \frac{2}{z_{max}-z_{min}} & \frac{z_{max}+z_{min}}{z_{max}-z_{min}} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Perspective Transformation

- Apply rotation matrix to map eye position to center of scene to negative *Z* and up to *Y* axes
- Scale *(x,y)* inversely proportional to distance
- Scale to canonical volume



From: *OpenGL Red Book*

gluPerspective(fovy,aspect,Znear,Zfar)

Let θ = fovy/2

gluPerspective Projection Matrix

$$\begin{pmatrix} \frac{\cot\theta}{aspect} & 0 & 0 & 0 \\ 0 & \cot\theta & 0 & 0 \\ 0 & 0 & \frac{z_{far}+z_{near}}{z_{far}-z_{near}} & \frac{2z_{far}z_{near}}{z_{far}-z_{near}} \\ 0 & 0 & -1 & 0 \end{pmatrix}$$

gluPerspective(fovy,aspect,Znear,Zfar)

- *fovy* is the angle in the up/down direction
- *aspect* is is the horizontal to vertical ratio
- *Znear* is the distance to the near clipping plane
  - Killer fact Znear > 0
- *Zfar* is the distance to the far clipping plane
  - *Zfar* > *Znear*
- *Zfar-Znear* determines *Z* resolution since the Z buffer has finite precision

gluLookAt(E_x,E_y,E_z , C_x,C_y,C_z , U_x,U_y,U_z)

- (E_x,E_y,E_z) is the eye position
- (C_x,C_y,C_z) is the position you look at
- (U_x,U_y,U_z) is the up direction
- *C*-*E* determines the distance in the *Z* direction
- The *Z* distance to each object (from E) determines the reduction in the *(x,y)* direction