UCLA

CS174A : Introduction to Computer Graphics

Kinsey 1240
MW 4-6pm

Scott Friedman, Ph.D
UCLA Institute for Digital Research and Education

Introduction

- Scott Friedman
  - MS, Ph.D in Computer Science
  - B.Arch, M.Arch in Architecture
    - Founding member of UCLA Urban Simulation Team
      - » http://www.ust.ucla.edu
  - Thesis on Real-time parallel rendering
  - Chief of Technology for UCLA Research Computing
    - High Performance Research Computing, Networking and Storage

Introduction

- Contact
  - You should feel free contacting us by email.
  - Use the course forum (Piazza)
    - Good for common questions/answers
  - If you need to see me –you must- set up an appointment.
    - Office is 3344 Math Science Building
    - Office Phone is 310-825-8607
    - Email is best. friedman@ucla.edu
  - Text
    - Interactive Computer Graphics – A Top-Down Approach with Shader-Based OpenGL, **7th Edition**, Angel & Shreiner

Course Administration

- Four* Assignments (Programming)
  - Three progressive that build on each other
  - Extra credit offered
  - First is simple 0 point excercise
- Mid-Term Exam (optional)
- Term Project (Programming)
  - This will be the meat of your experience!
- Final Exam (optional)

Course Administration

- Grading
  - We will use a point system
  - 1000 points plus extra credit
  - Extra credit available
  - Specific tasks assigned points.
  - No curve
  - Grade to point breakdown on syllabus

Course Administration

- Programming Assignments
  - #1 100 points
  - #2 150 points
  - #3 50 points
    - Extra Credit options will be available for these assignments.
    - Exact details of what you have to do will be outlined in the assignments.

Course Administration

- Programming Assignments
  - Assignments will exercise your understanding of the course elements to prepare you for the term project.
  - They will build on each other so keeping up with the assignments in important.

Course Administration

- Mid-Term Exam (50 points) (optional)
  - The test will be open book
  - Closed laptop/phone/network, everything else
  - Concept based: multi-choice, short answer
  - If you are comple the assignments and read the book you should be just fine.
- Hackathon option (200 points)
  - Live programming exercise

Course Administration

- Final Exam (50 points)
  - Same arrangement as the Mid-Term Exam
  - If you are attending the lectures
  - Doing the assignments and project
  - Asking questions
  - Using your brain
  - You should be just fine

Course Administration

- Term Project (600 points)
  - You *will* write a *non-trivial* graphics program.
  - It *will* include some type of user interaction.
  - You *will demonstrate* your work *live* in front of class.
  - You *will* work in a team.
    - Teams are three to five people.
  - All team members will receive the same points
  - Requirements *will* go up proportionally to the number of people in your team!

Course Administration

- Term Project – details
  - Groups from three (3) people to max of five (5)
  - All projects must include techniques through texture mapping
  - Plus one "advanced feature"
  - Additional "advanced feature" required for each group member above three.
    - If you have a five member group you will need three advanced features.

Course Administration

- Term Project (600 points)
  - Start thinking about this **now**
    - Team?
    - Ideas?
  - Be careful not to get yourself into a bind.
  - You *will* all vote on each others during the final week of class!
  - It will be fun…right? :)

Course Administration

- Term Project (600 points)
  - 300 points from professor and Tas
  - 100 points from teammates (average)
  - 200 points from classmates (demo)
- Extra points for
  - Class favorite, most impressive and maybe some others based on class voting

Course Administration

- Something to Remember
  - If you do the Assignments
  - Take the Exams
  - Complete the Term Project
  - …and do not bother with extra credit
  - It is still possible to get an A
  - The extra stuff is for those of you who
    - Want to challenge yourself (or show off)
    - Avoid the exams
    - Have some extra fun
    - Something to show during interviews…

Course Administration

- Expectations
  - You pay attention and show up
  - You do your work with integrity
  - You stay off your phone/texting/chat/twitter/…
  - You are proficient programmer
    - You will become one by the end of this quarter whether you like it or not! ☺
  - You can set up a development environment
  - You have some idea of how to debug
    - The TAs *will not* debug your work for you
  - You really need your own computer (laptop)

Course Administration

- Development Environment
  - Again, you really should have your own stuff
    - You do don't you? Less fun if you do not…
  - I am being unreasonable about this?
  - Linux, OSX, Windows all ok – I do not care
  - We will be using WebGL in this class
    - Should simplify things…
    - You can do your final projects on whatever, using whatever you like. Our ability to 'help' you will be directly proportional to our own experience and time
      - » Basically, you are on your own.

Course Administration

- TA's and discussion sections
  - We have 2 for 120 students
    - Garett and Sam (PhD students in graphics)
  - Use Piazza – please, that is where we will be
  - Use the web
  - Use each other
  - Sections typically for QA
    - Occasionally for more detail (linear algebra)
    - Explaining stuff better than I do (!)

Course Administration

- Purpose of Class
  - Learn basic computer graphics and interaction
  - Use *all* of your CS skills
  - Help each other
  - HAVE FUN!
- More detail in Syllabus
- Questions?

A little motivation…

- Computer Graphics? How boring!

A little motivation…

- Computer Graphics? Not! It is everywhere!

A little motivation…

- Movies!

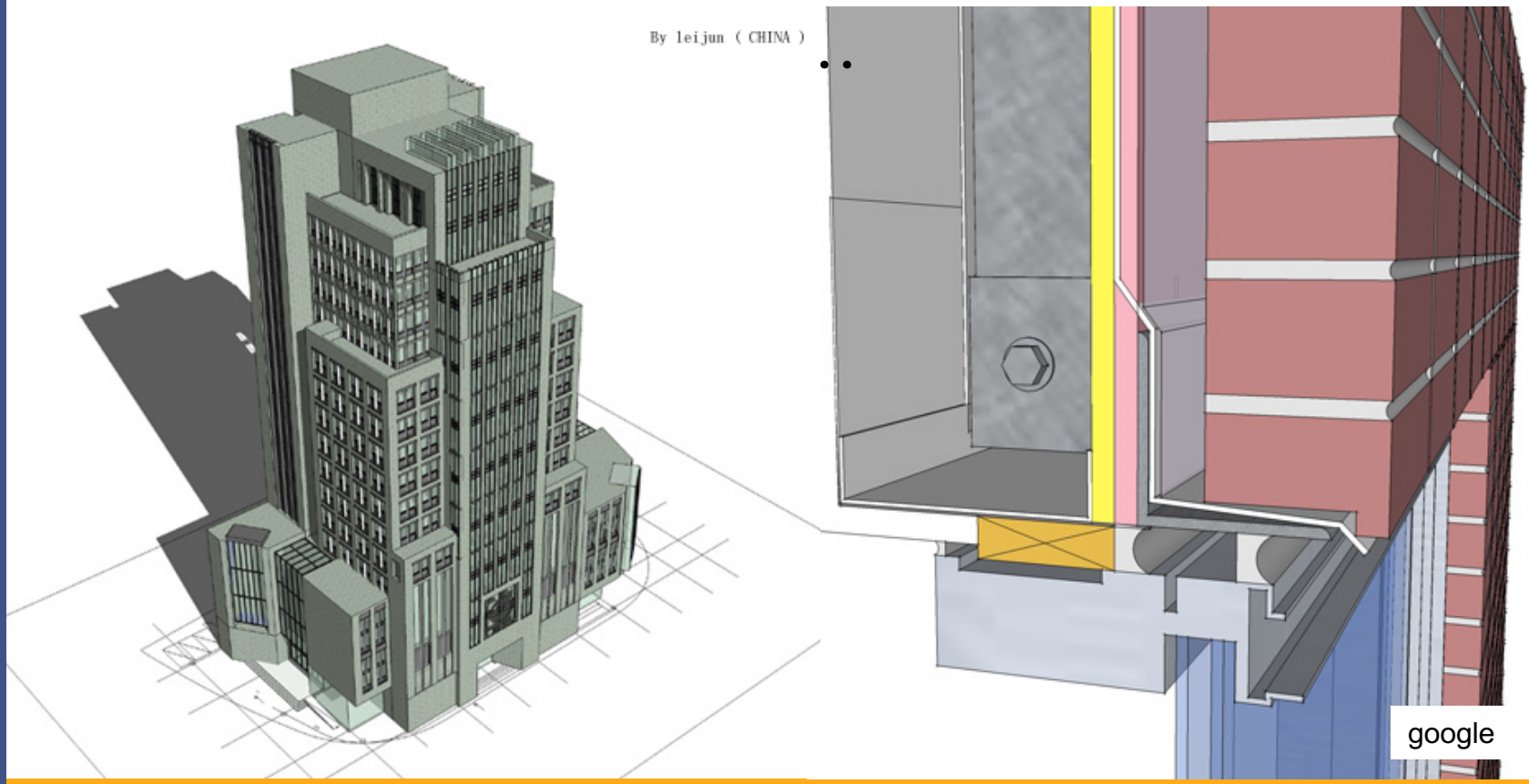
A little motivation…

- Games! …a larger business annually than the movies
  - It is everywhere today…

id software

A little motivation…

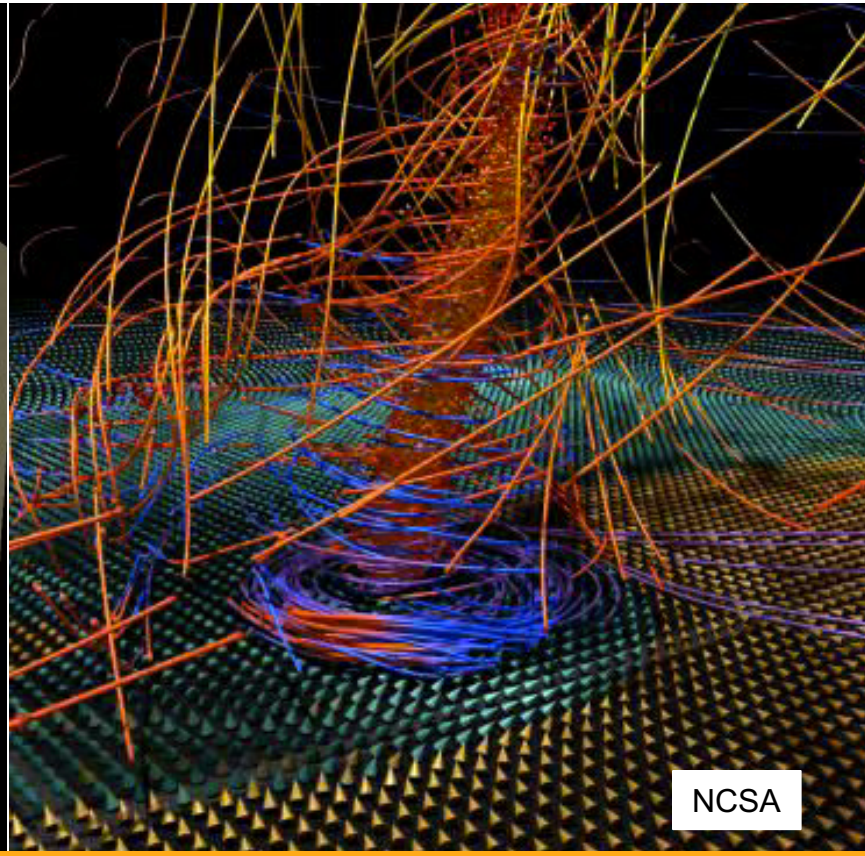
- CAD!



google

A little motivation…

- Scientific Visualization!



A little motivation…

- Simulation and Training!

Lockheed F35 Trainer

A little local history…

- UCLA not typically known for graphics
- Or is it?
- UCLA Architecture and Art
  - Home of 'Processing'
  - Robert Abel (one of the first customers of SGI)
  - CAD Pioneers
  - Early developers of VR technology

A little local history…

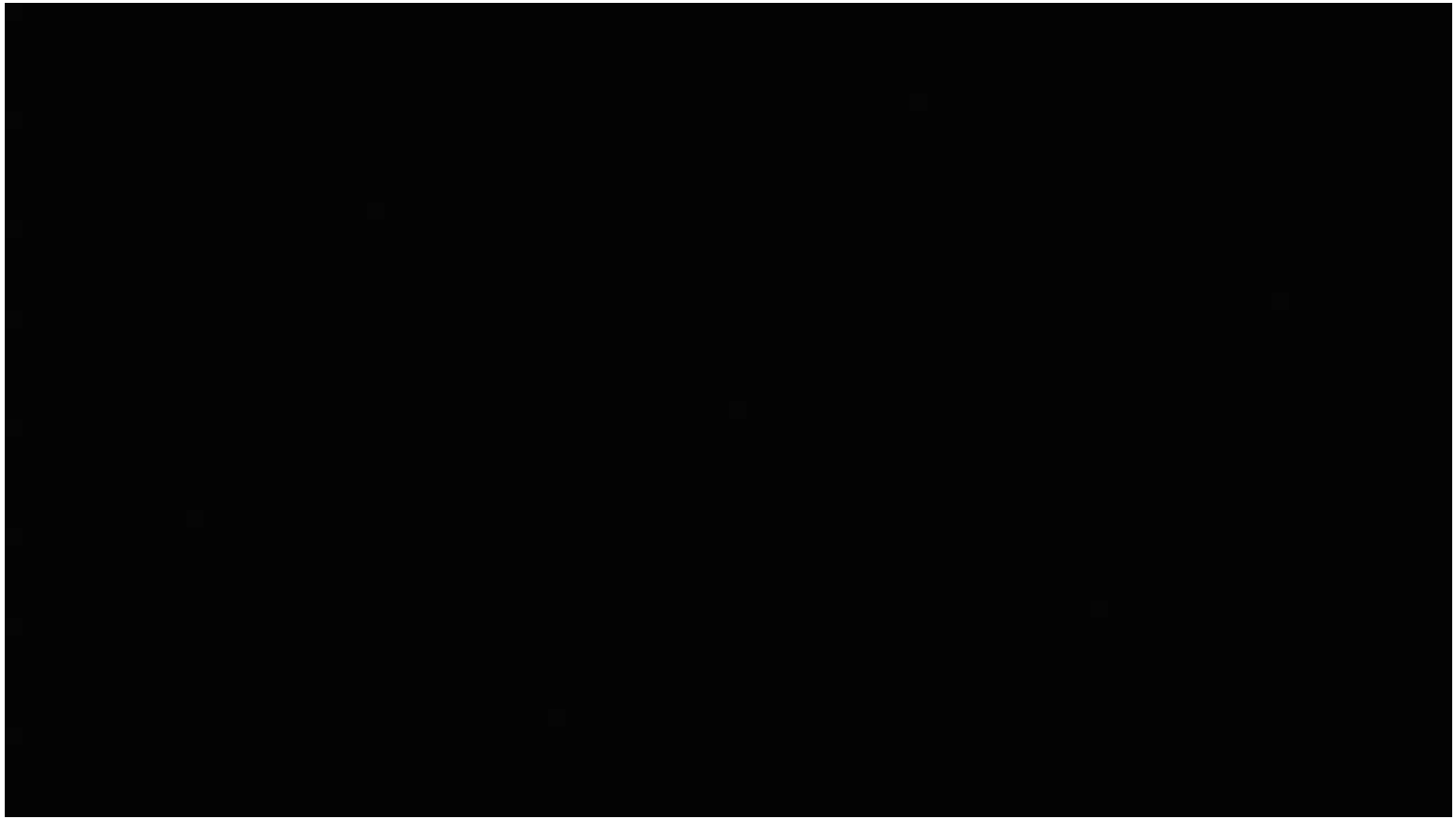
- How Early?
- NASA Apollo Lunar Docking Simulator
  - Built by General Electric in the late 60s
  - Render 40 polygons per second in real-time!!!
  - In color no less!
  - Later evolved into the Compu-Scene IV
    - First device to support texture mapping in hardware
    - Most successful fight simulator ever

A little local history…

A little local history…

- City-Scape led directly to the founding of the Urban Simulation Team at UCLA
- In the early days (20 years ago) we used big, expensive SGI computers.
- There have been more than 40 people who have been part of the Team (lab)
- The lab, unfortunately, is no more ☹

A little local history…



Let's get started…

- Top-Down Approach?
  - Lectures will focus on theory and detail.
  - Implementation should be up to you
    - This is not a class regurgitating the WebGL API
  - Means you will have something on the screen very quickly – in the next week.

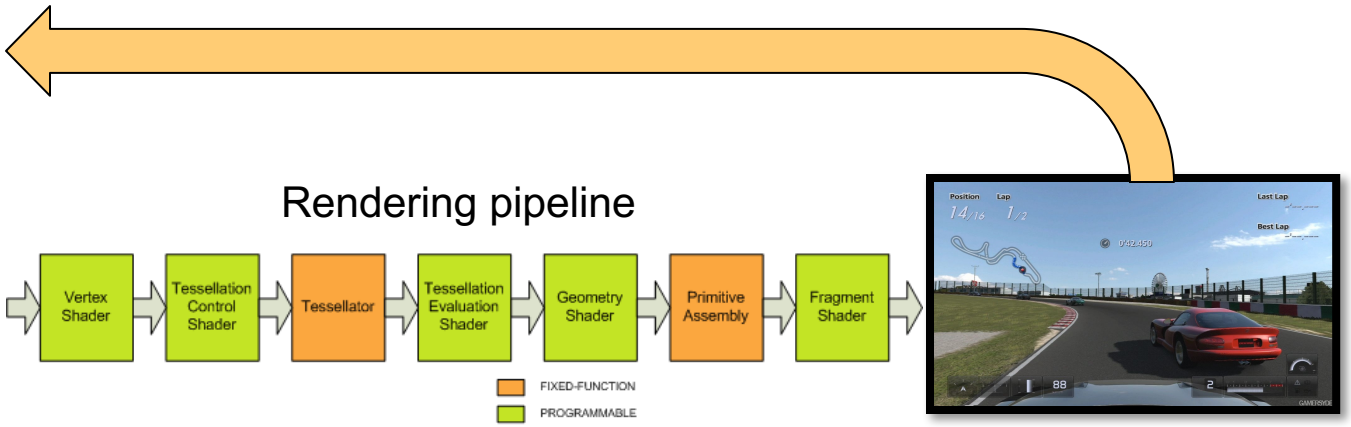
Let's get started…

- Two concepts are integral to the class

- Interaction (or event) Loop
- Imaging Pipeline
  - Concept of shaders is important in this class
- Understanding of the camera model

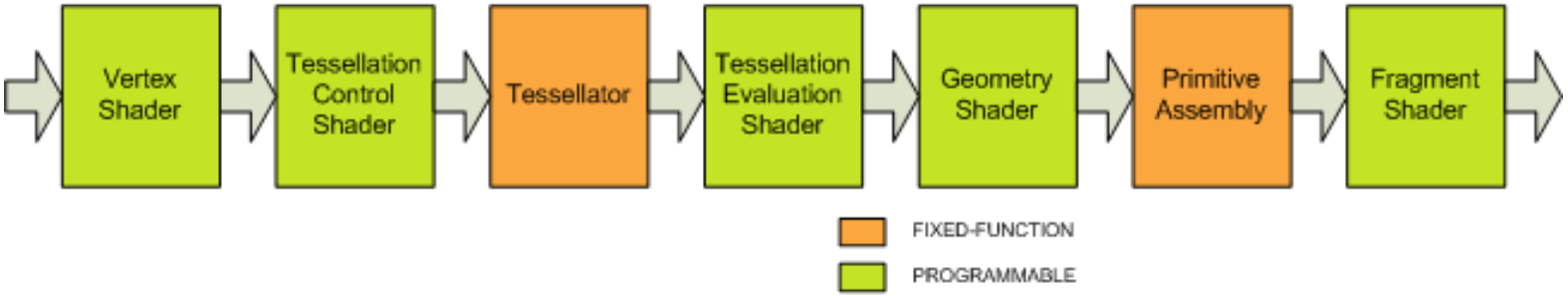
Interaction

- Interaction (or event) Loop
  - Collect User Input
    - From a mouse, joystick, finger, etc.
    - Send data to be displayed down the “rendering pipeline”
    - Display the result
    - Repeat



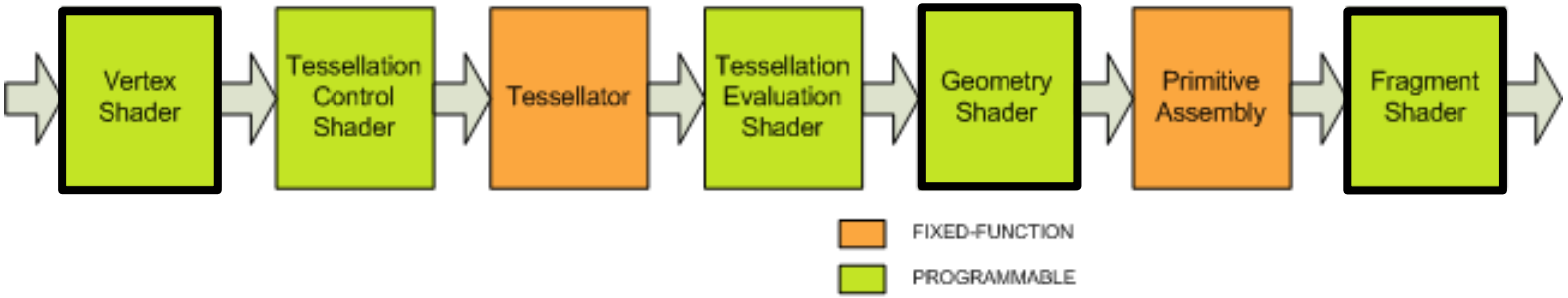
Rendering Pipeline

- Rendering Pipeline (OpenGL) what's that?
  - State Machine – old style fixed function
    - Colors, Textures, Lighting, think 'knobs' you turn
  - Shaders, think of little programs instead of simple 'knobs'
  - Geometry data passed in…
    - Projected, Rasterized, Colored (Visibility) and Displayed



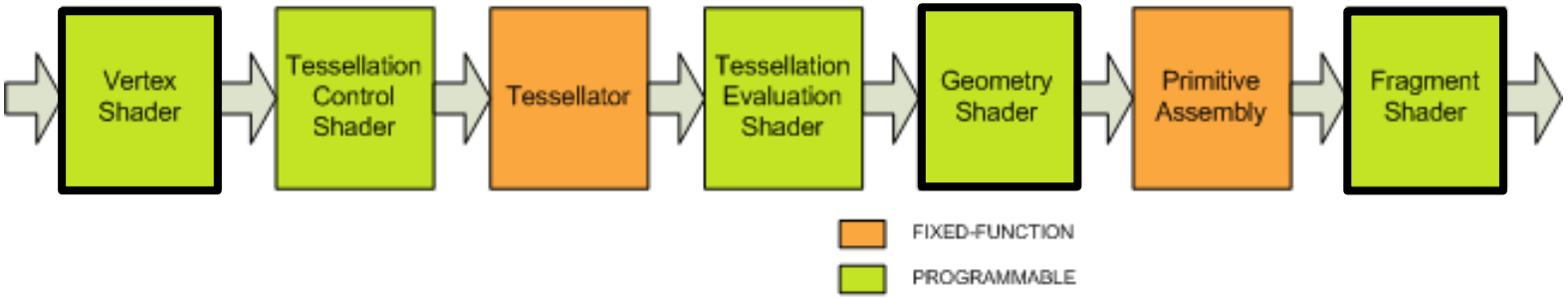
Rendering Pipeline

- Rendering Pipeline (OpenGL)
  - More complex than previous versions of OpenGL
  - This is the future (now) as all graphics hardware is programmable. (even on mobile devices)
  - Green boxes are programmable
    - We will focus on the highlighted boxes in this class
      - » Vertex, Geometry and Fragment



Rendering Pipeline

- Rendering Pipeline (OpenGL)
  - We will be writing little programs (shaders) that are executed on the graphics hardware to perform these different functions.
  - The thing to understand now is
    - The pipeline is hardware we access through the OpenGL/WebGL API that takes geometry as input and produces images as output.



Camera Model

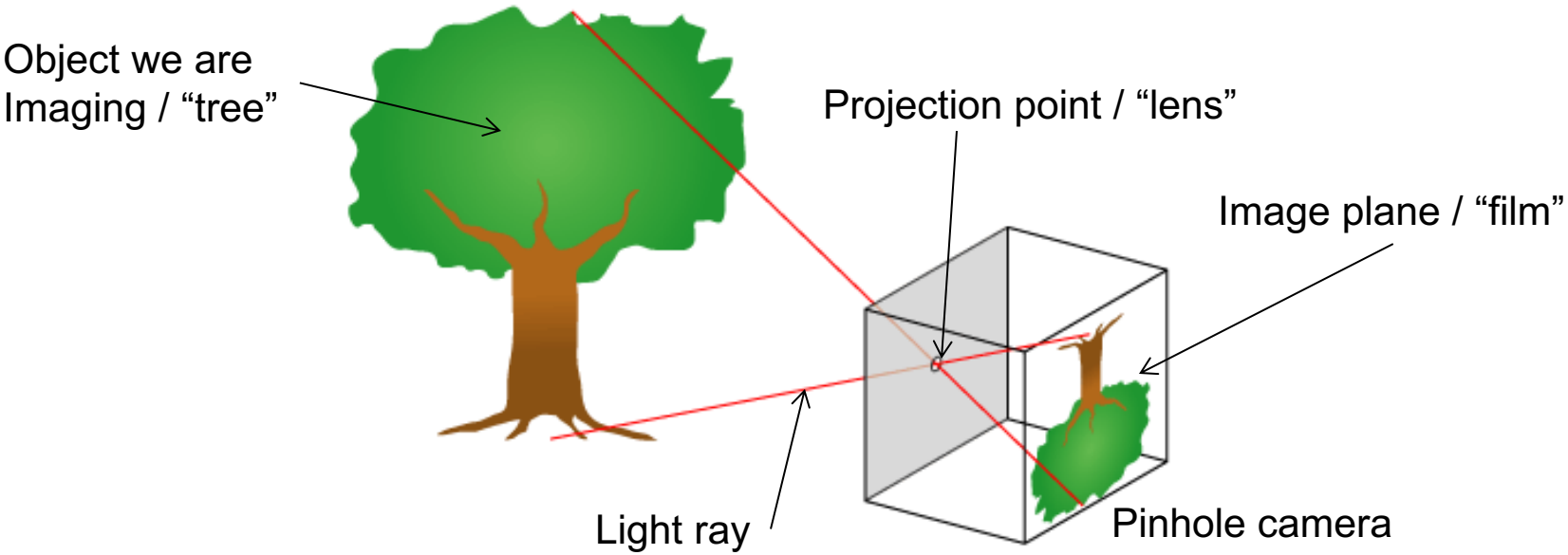
- One of the most important concepts to "get" is how we are forming an image on the display.
  - If you think of a camera, think of how an image is "captured" on the film/sensor (plane) as a metaphor.
  - In the computer we do not have light rays so we will approximate the same effect using math (geometry and linear algebra)
  - This will allow us to do quite a few things you could never do with a real camera!

Camera Model

- Using our camera metaphor what pieces do we need to form an image?
  - We need an object to form an image of
  - We need some kind of "lens"
  - We need someplace on which to form the resulting image, some "film"
- In a real camera the light rays "project" through our lens to form an image on the film.

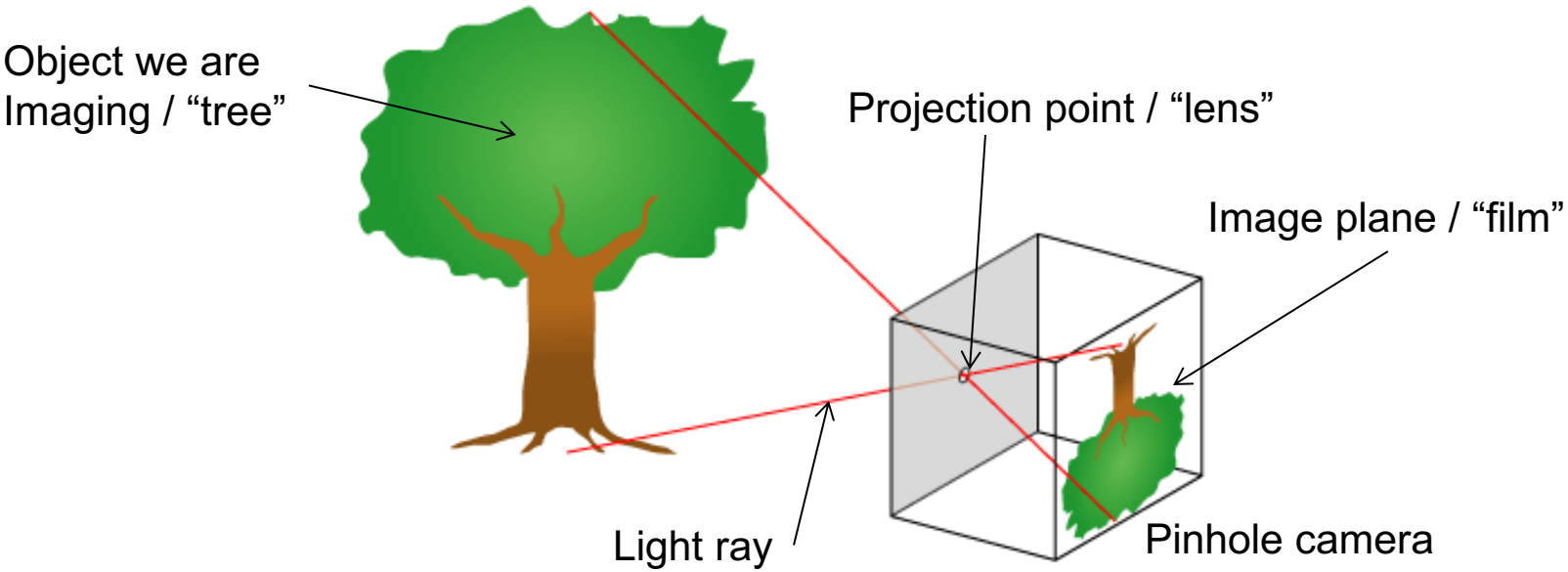
Camera Model

- A pinhole camera has a very simple "lens"
  - A tiny hole to let light rays through
  - Lets call this the "projection point"



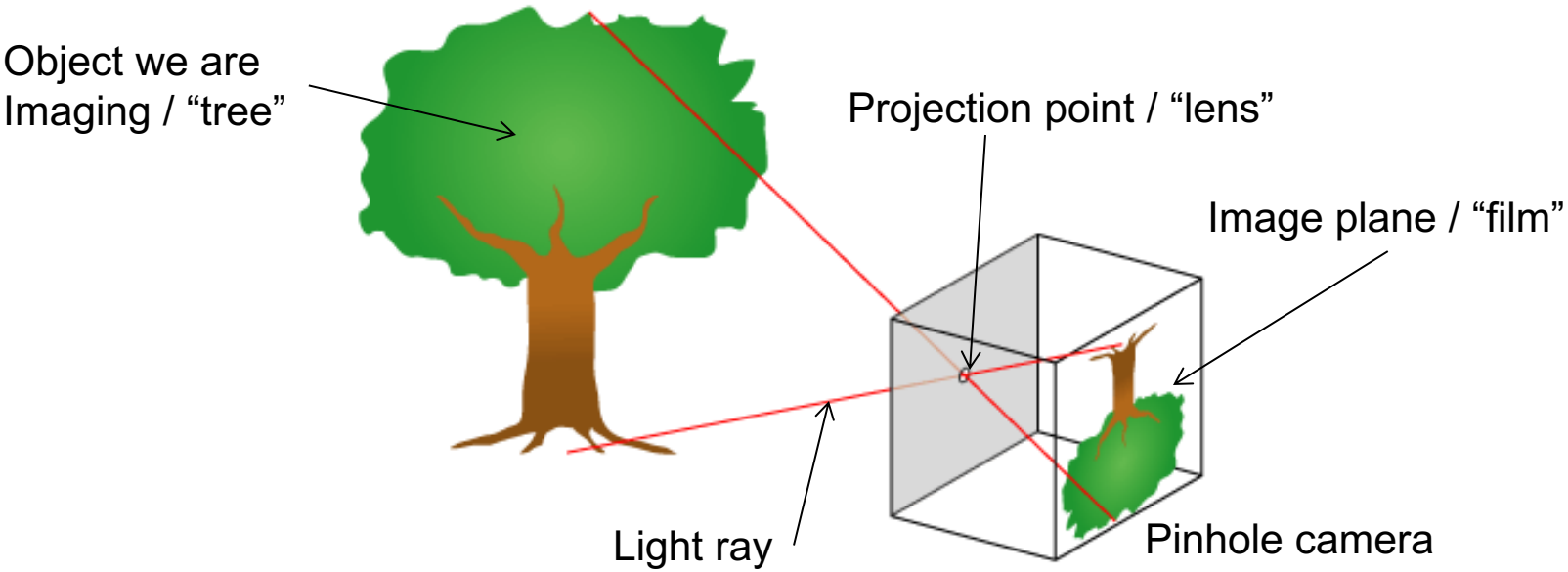
Camera Model

- Let's turn this around
  - Let every point covering the "film" capture what it can "see" through the projection point (lens)



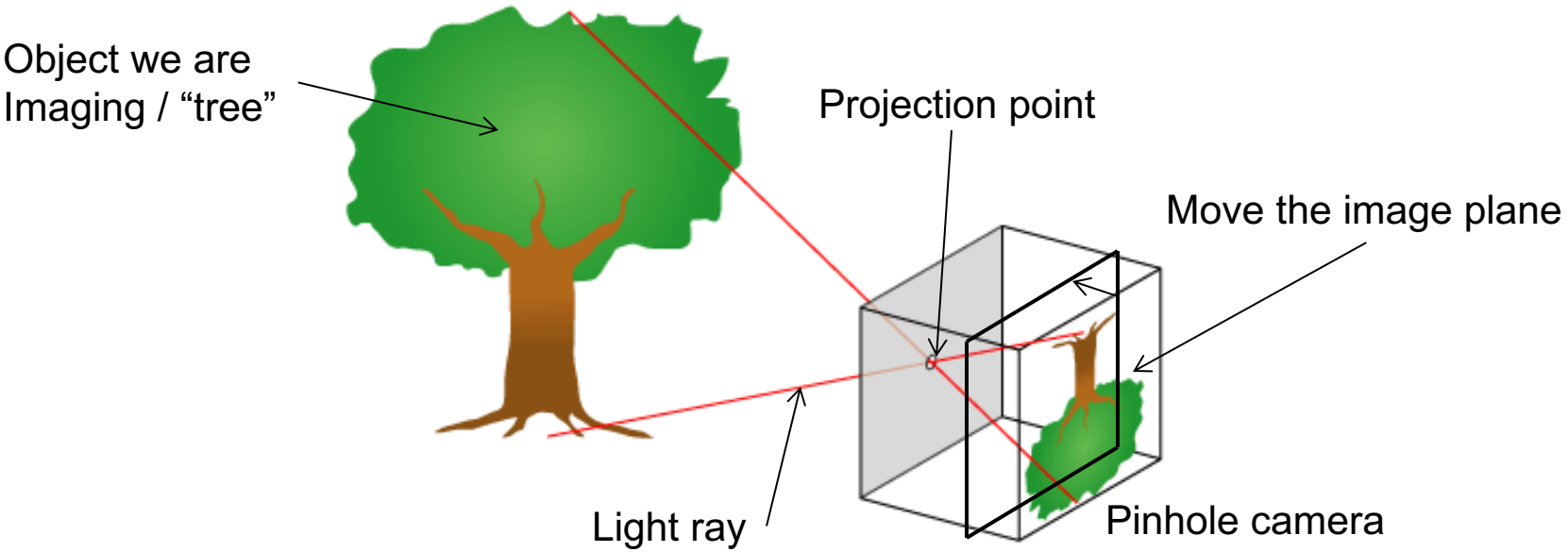
Camera Model

- Can you imagine what would happen to the image of the object if we moved the image plane (film) relative to the projection point? (closer/farther)



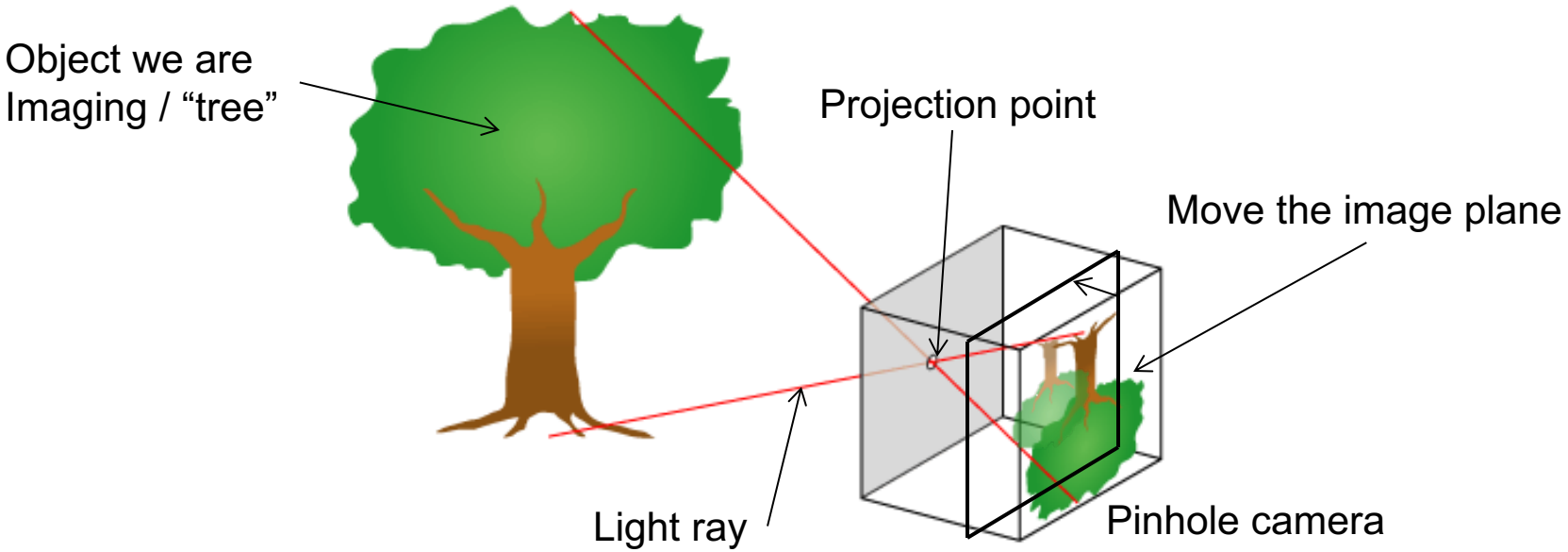
Camera Model

- As we move the image plane *closer* to the projection point, what would happen to the *object* we are imaging?



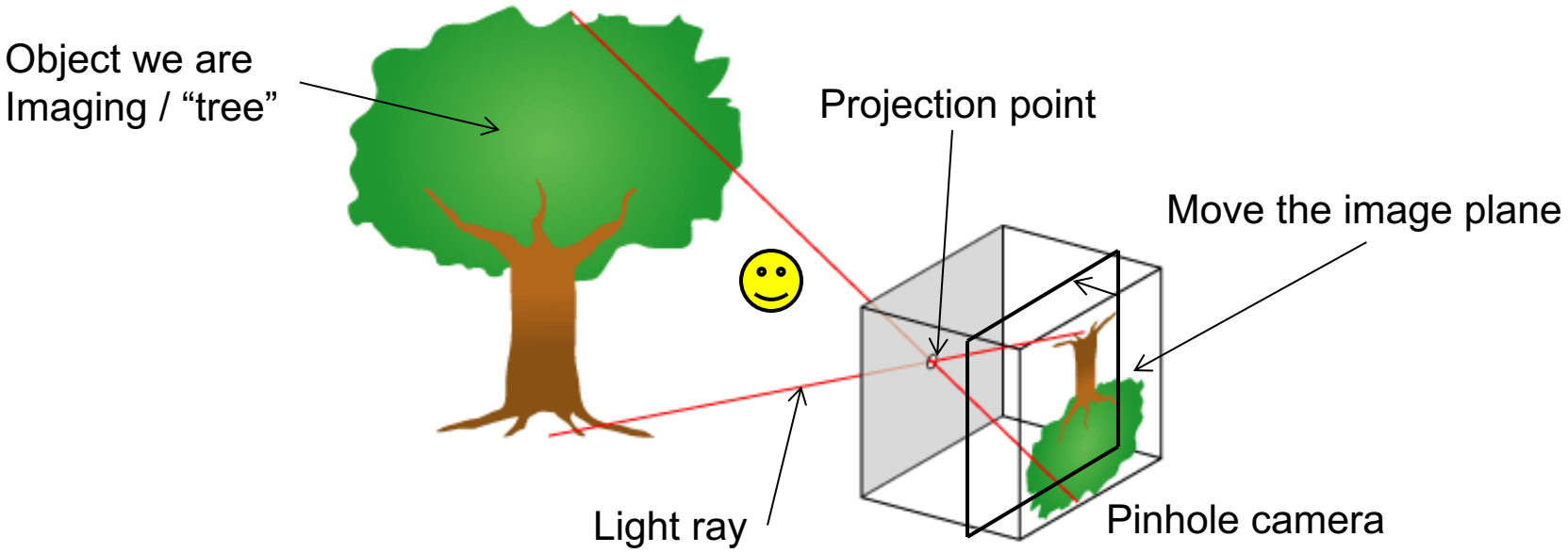
Camera Model

- As we move the image plane *closer* to the projection point, what would happen to the *object* we are imaging? ***It would get smaller.***



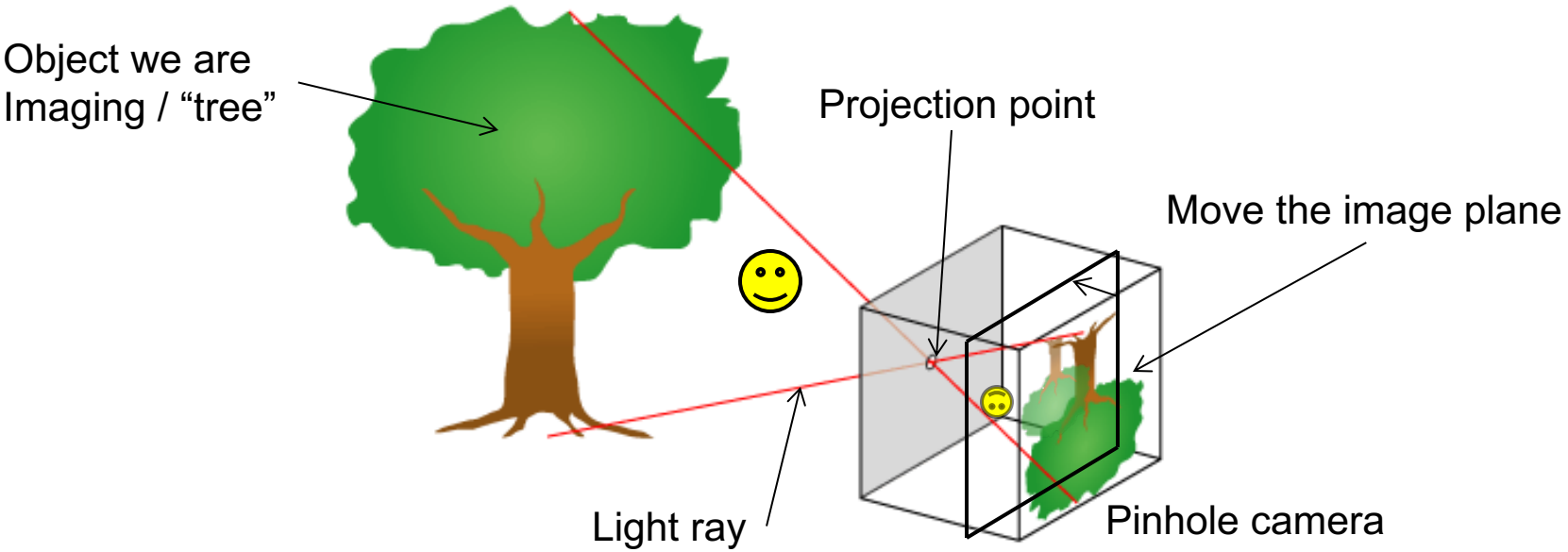
Camera Model

- What happens to the image that is formed, *overall*, as the image plane is moved closer to the projection point?



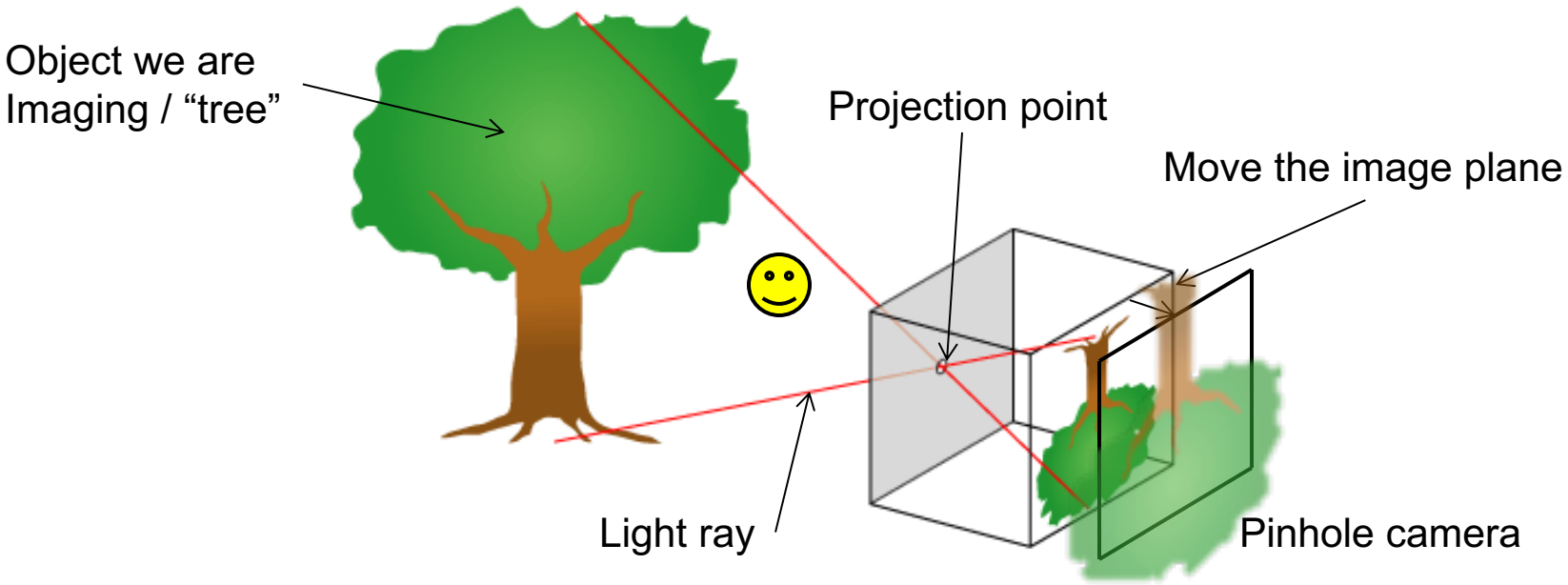
Camera Model

- What happens to the image that is formed, *overall*, as the image plane is moved closer to the projection point? ***It covers more area.***



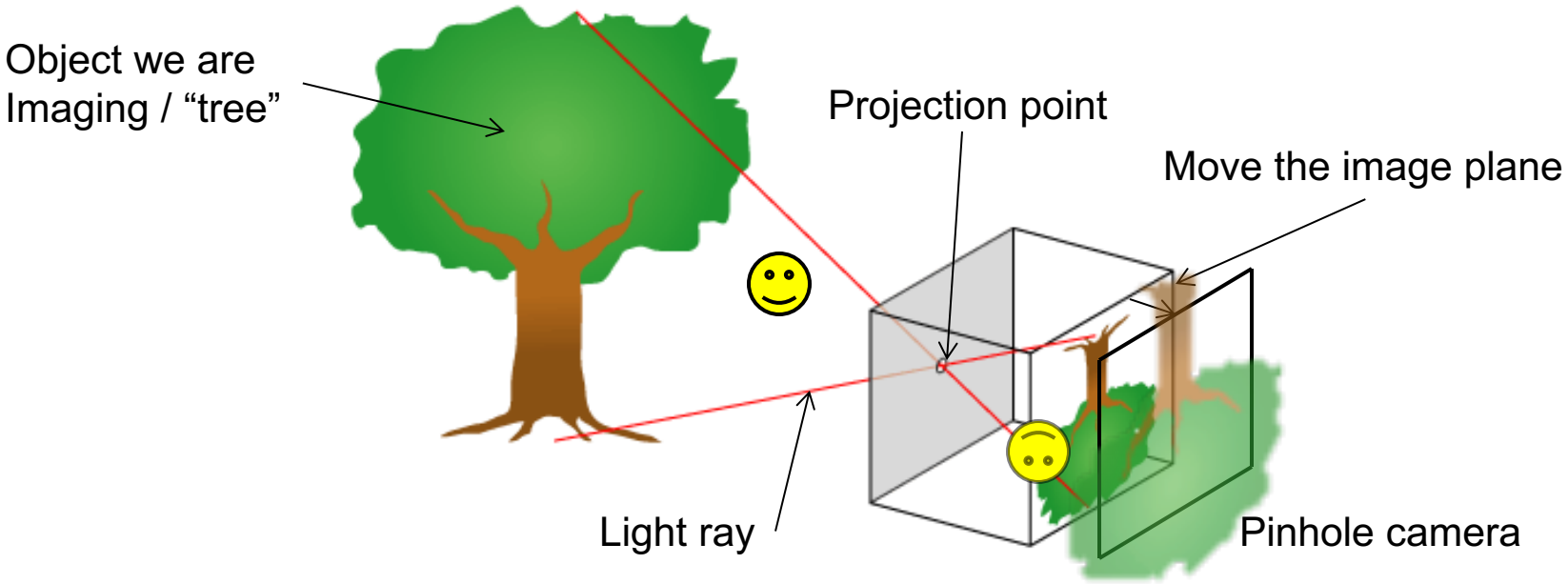
Camera Model

- Conversely, if we move the image plane *away* from the projection point the resulting object ***gets larger.***



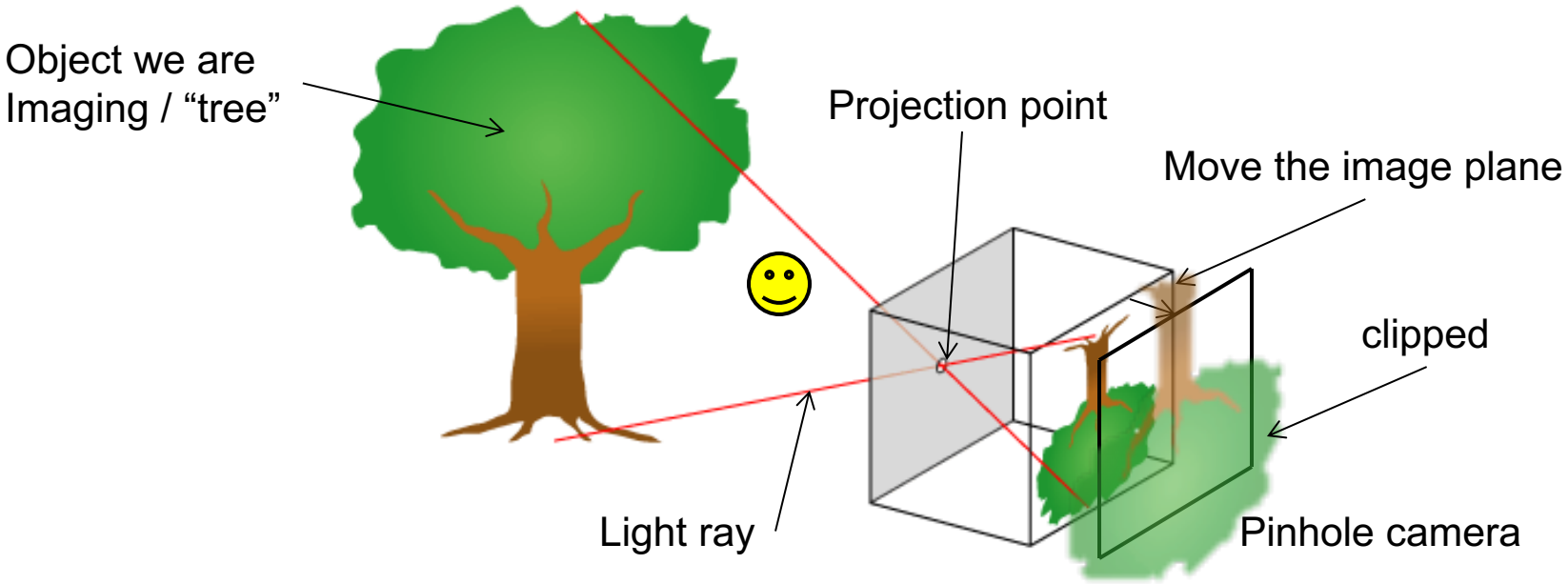
Camera Model

- However, because our image plane (film) is a fixed size we are able to capture less area of the scene.



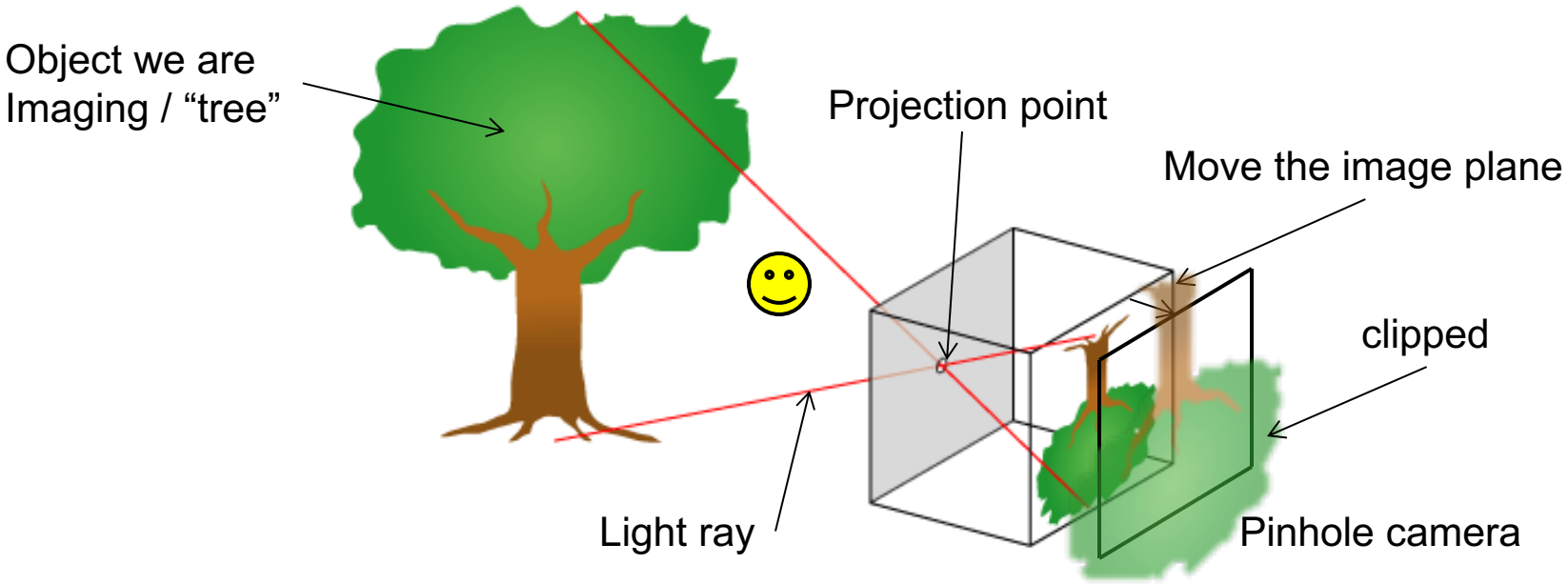
Camera Model

- In CG we call the process of eliminating the stuff that is out of bounds *clipping*.
  - *In this case, the edges of the tree are clipped from the film.*



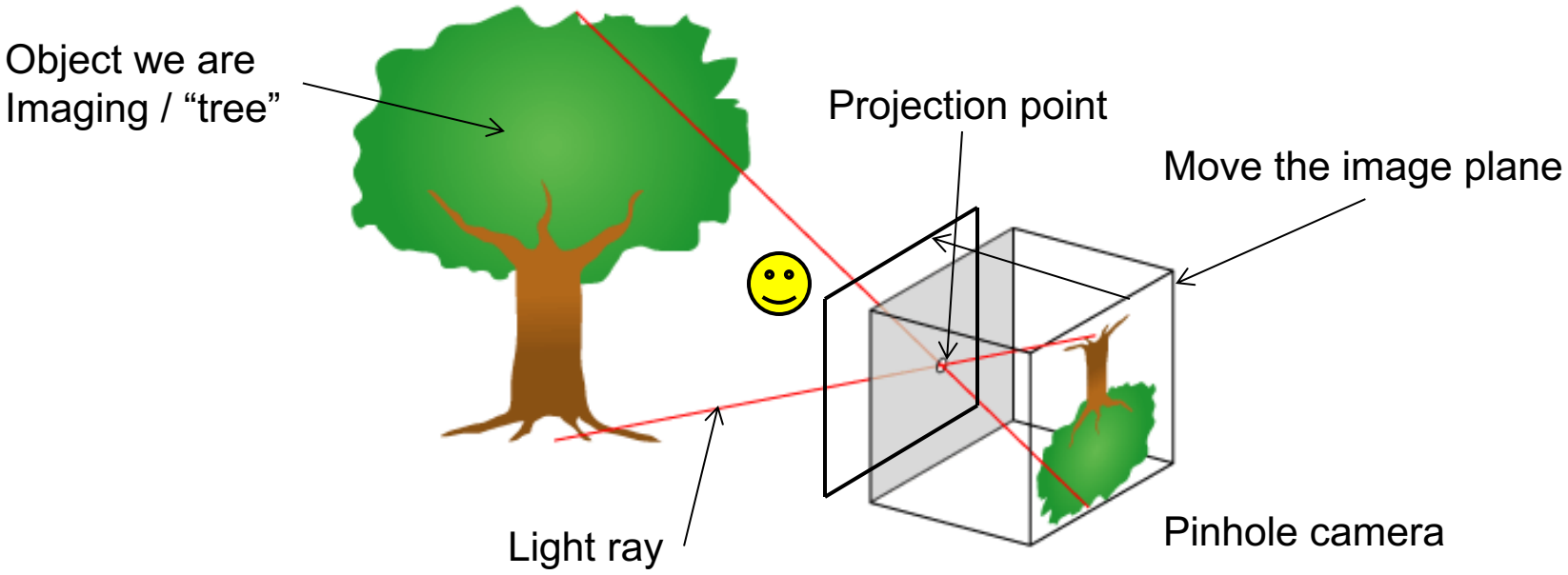
Camera Model

- In 2D we call it *clipping*.
- In 3D we call it *culling*.
  - We will spend more time on this later.



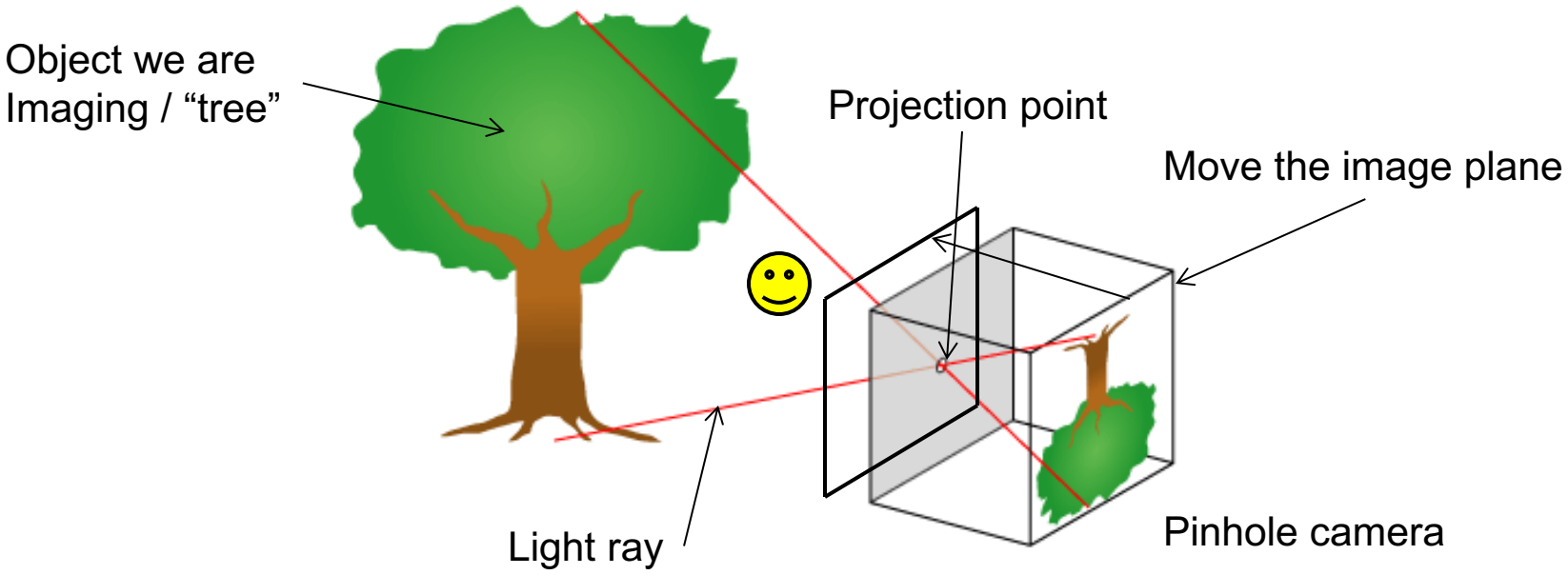
Camera Model

- What would happen if I moved the image plane *in front of* the projection point?
  - Can I do this? What would happen?
  - Can't do this with a real camera



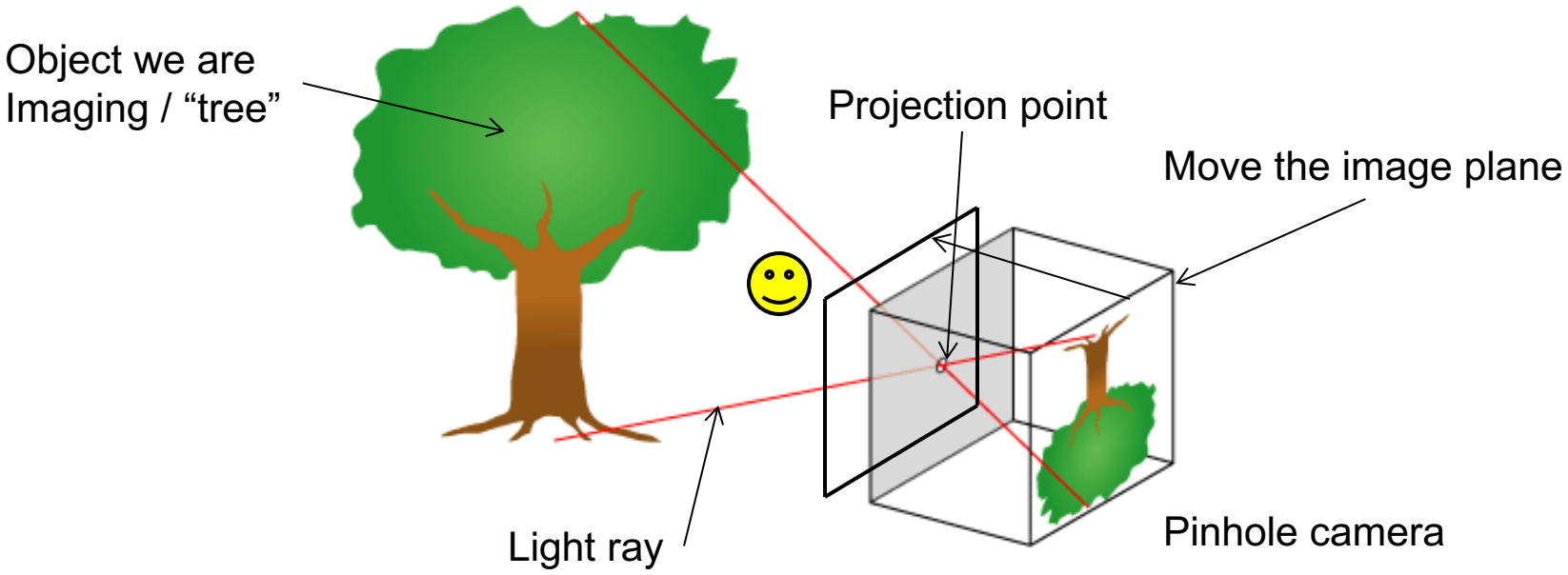
Camera Model

- Think carefully!
- Understanding this is integral to the class.



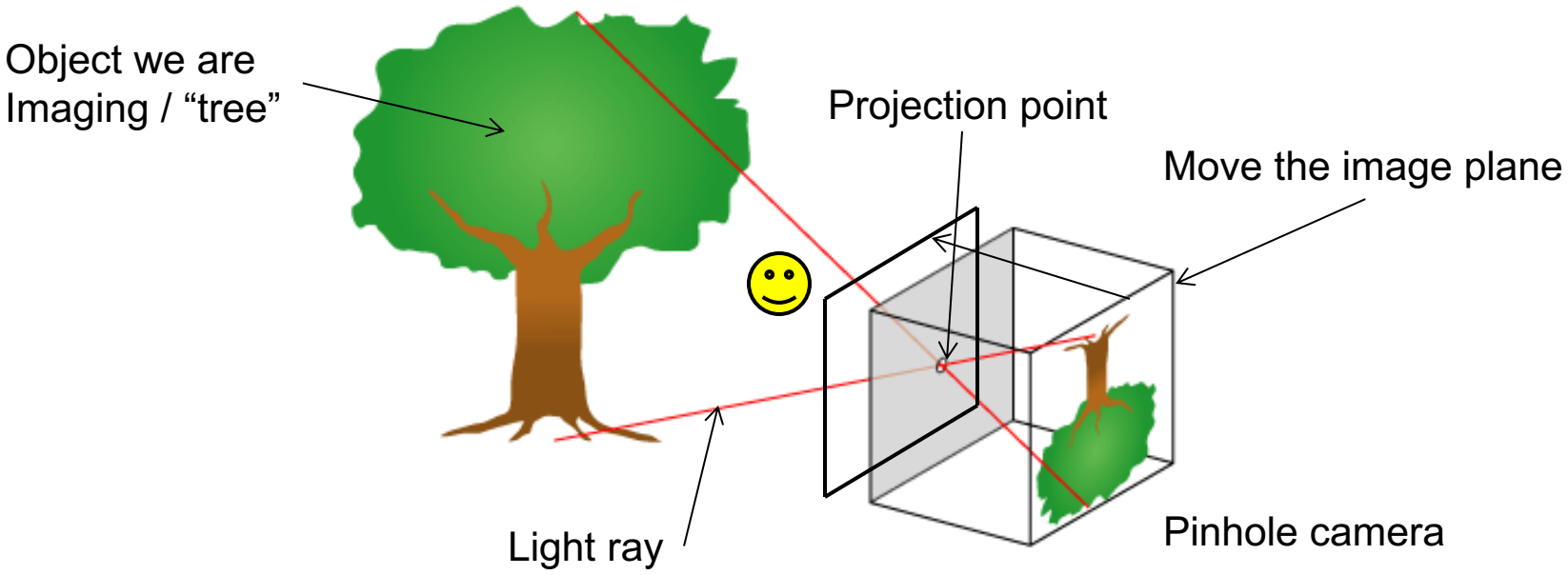
Camera Model

- Abstracting things (even more)
  - Pass a ray through the projection point and each point across the image plane.



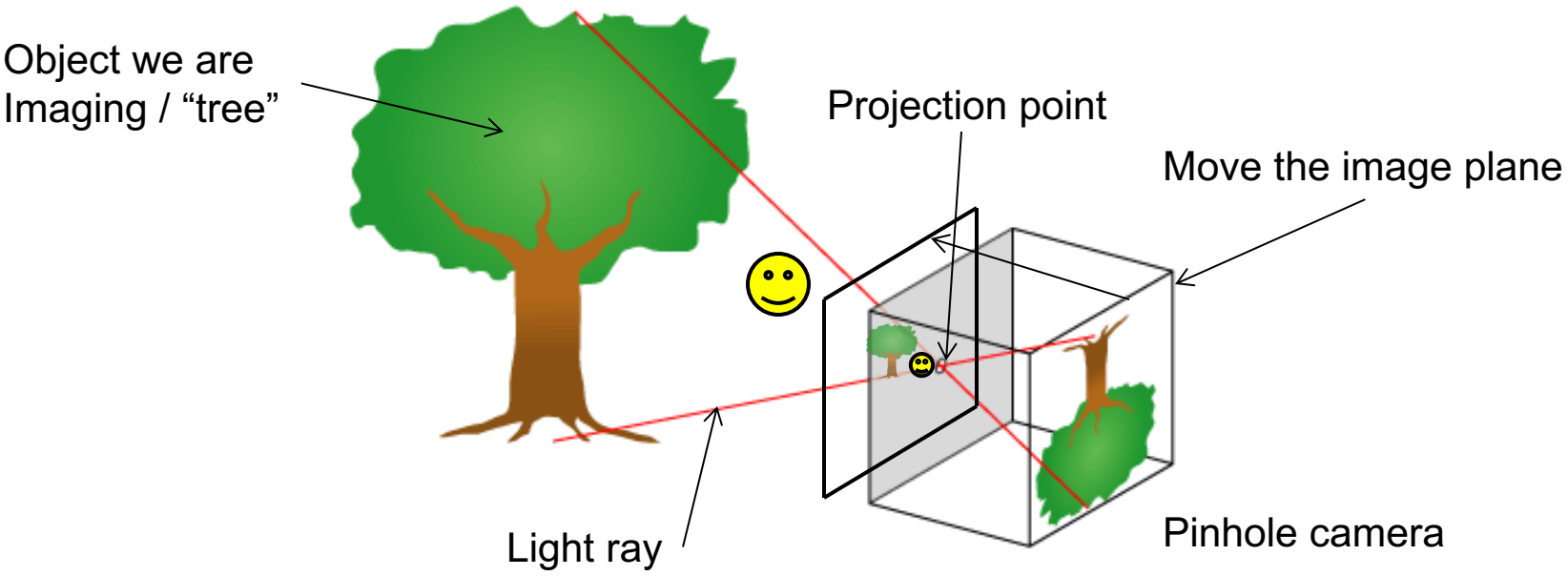
Camera Model

- What will the scene look like?
  - Will the tree be larger or smaller?
  - Is more or less captured on the image plane?
  - What else happens?



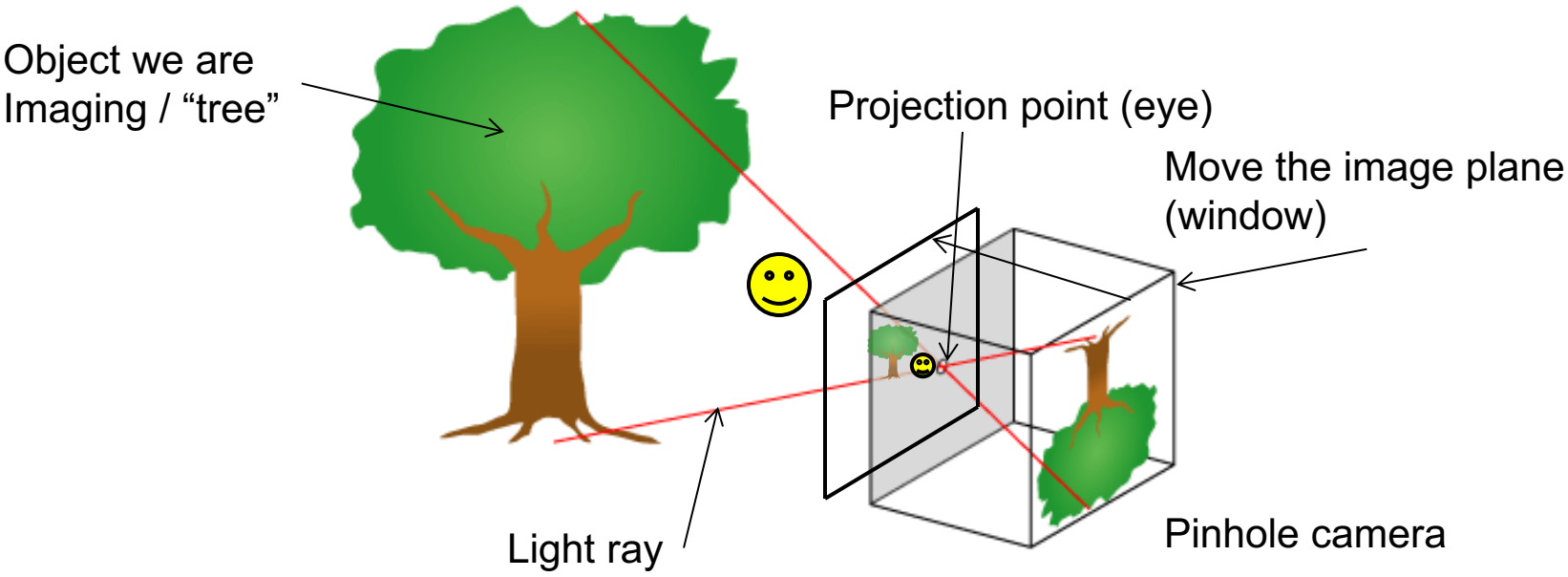
Camera Model

- What happens is…
  - Either depending on position of image plane.
  - Image is right side up!
    - In this example, image is smaller and covers more area.



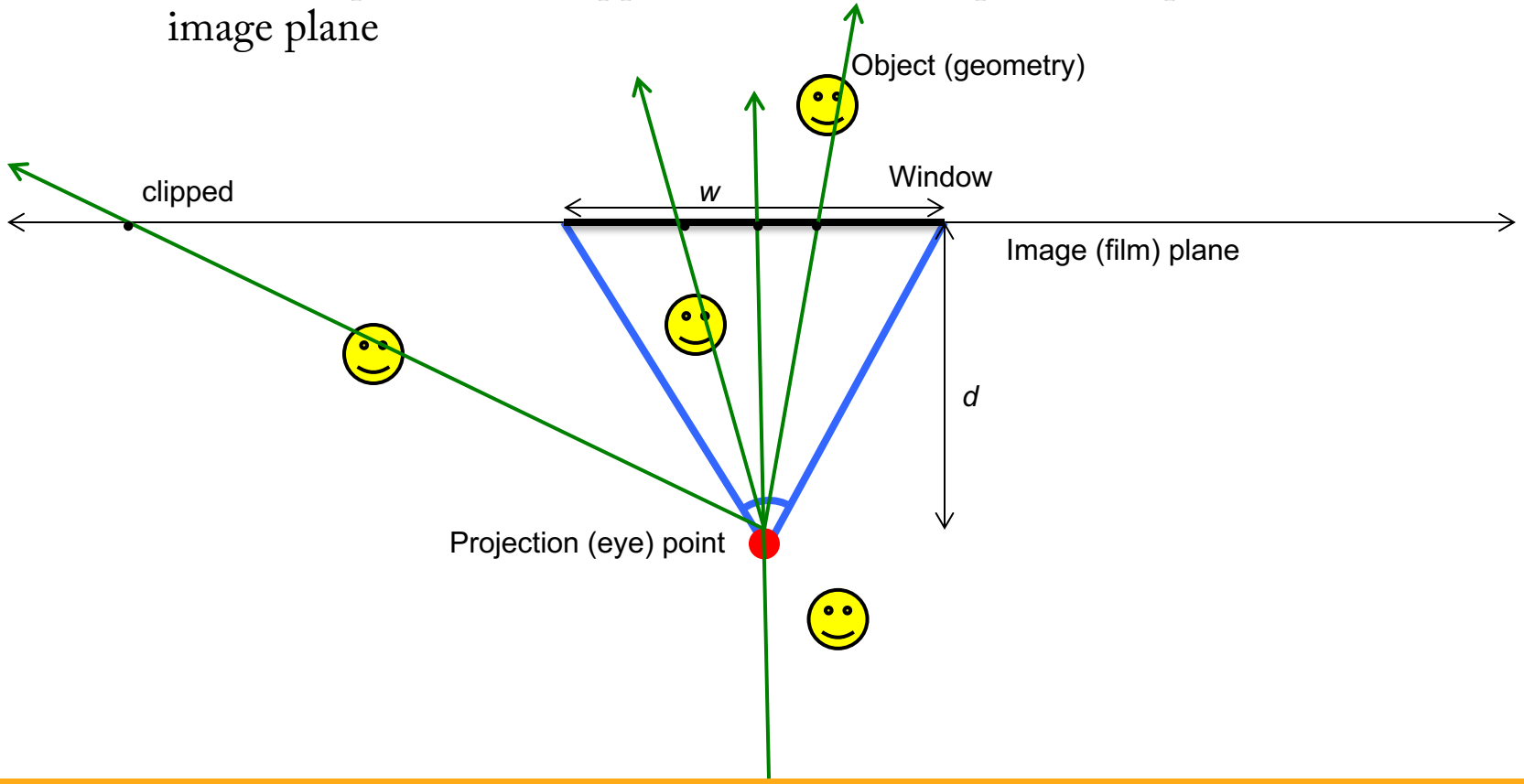
Camera Model

- Make sense?
  - We will be computing the projection (intersection) of an object (geometry) onto the image plane (window) using the projection point (eye), limiting what we see by clipping.



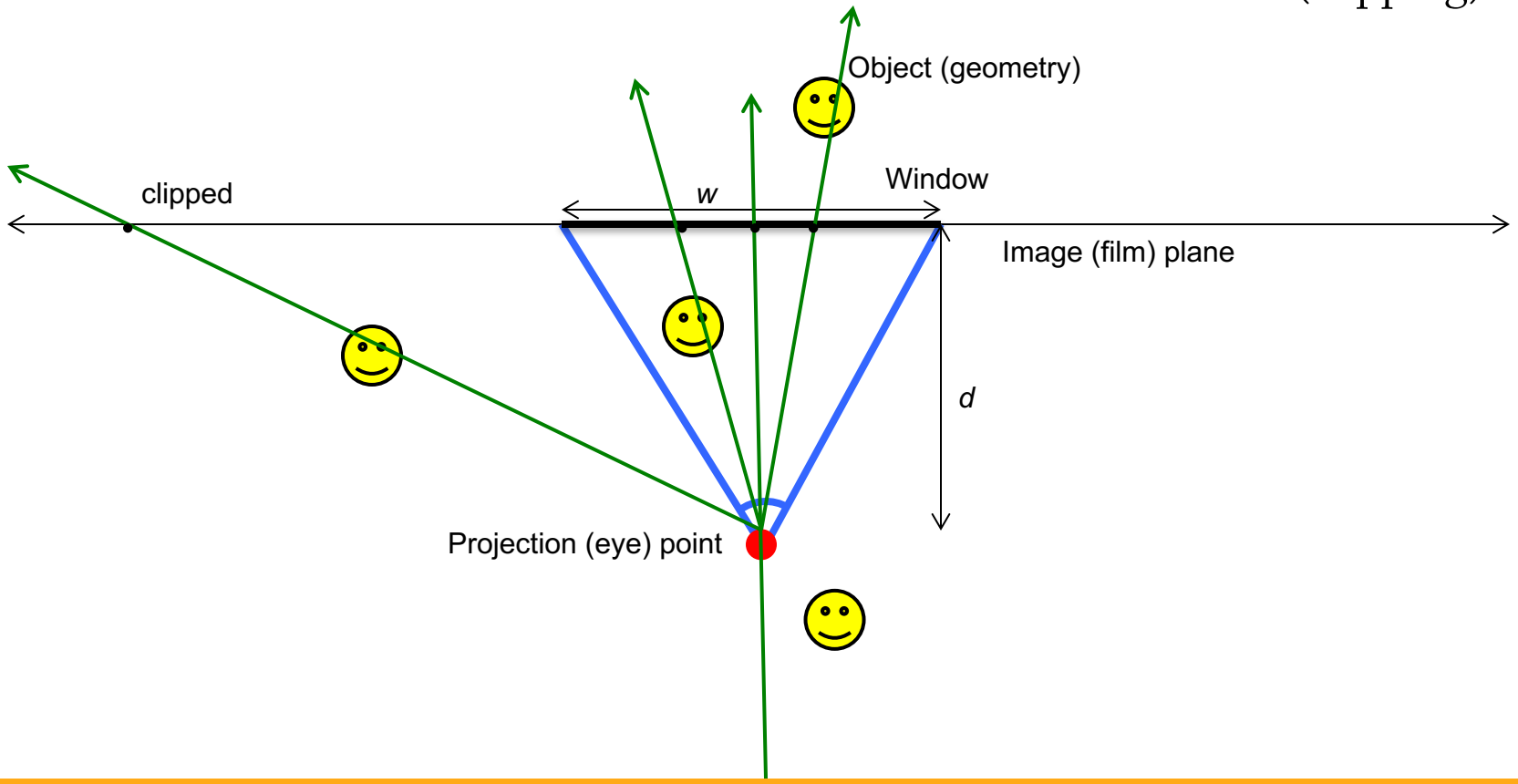
Camera Model

- Look at it this way…from above
  - We could project any happy face through the projection point onto the image plane



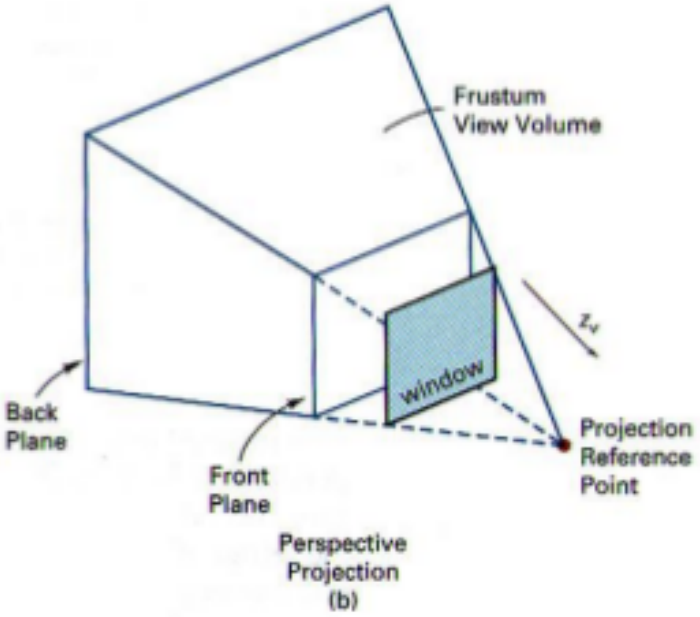
Camera Model

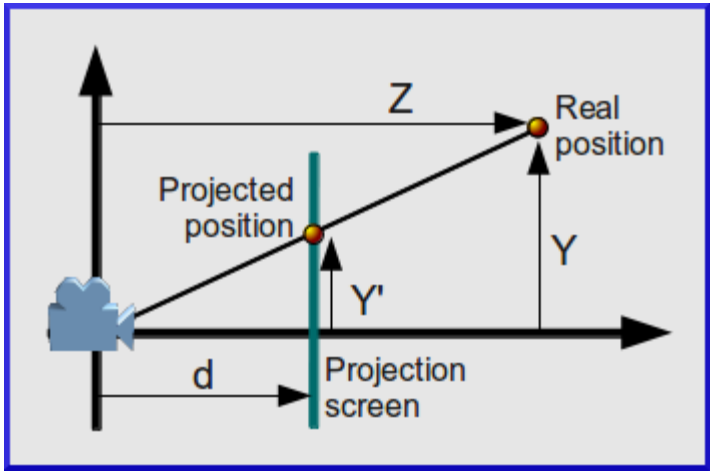
- Windows help limit what we need to render
- The definition of the window determines what will be visible (clipping)



Camera Model

- So, like a physical camera, but not exactly
  - We can do things cameras cannot do
  - Windows and Frustums help us limit what we consider for projection.





Camera Model

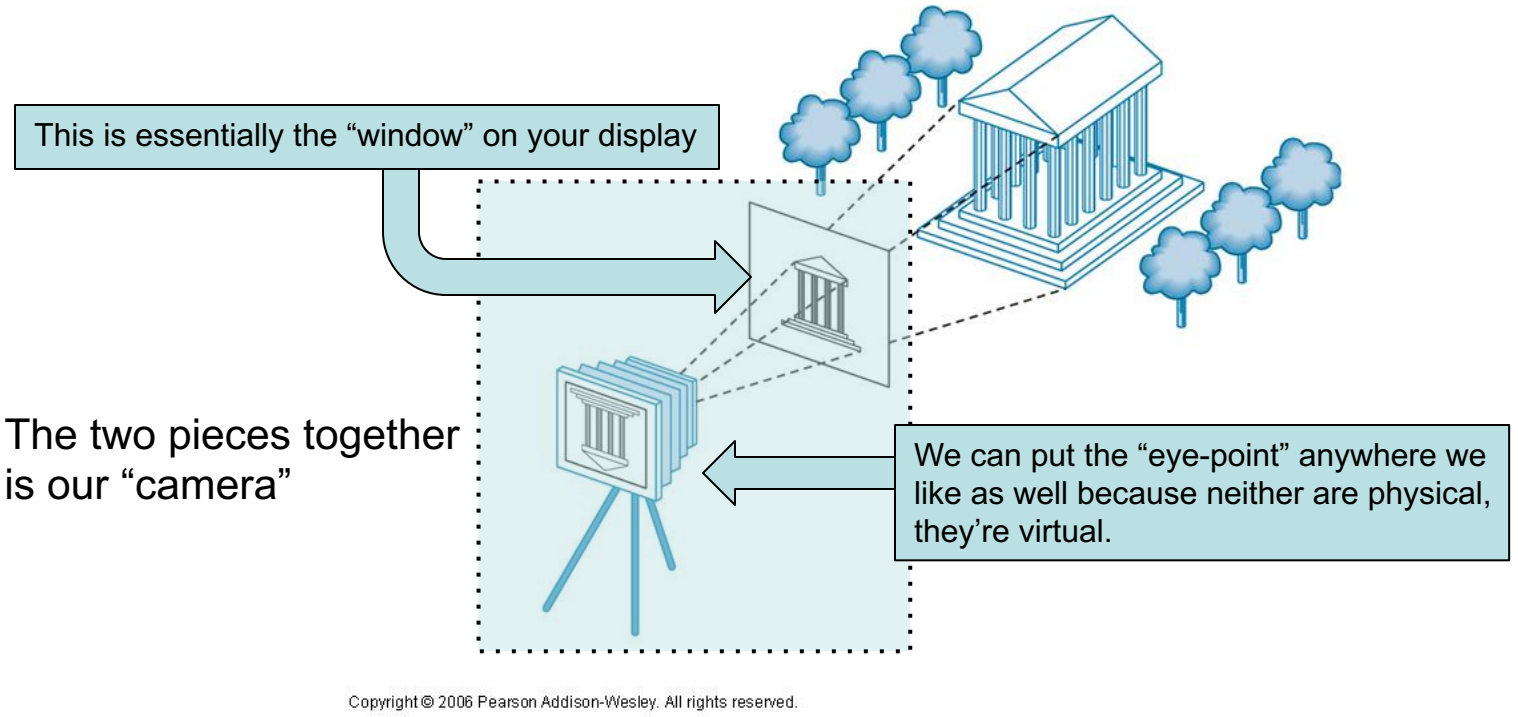
- Our camera, then, is defined by the relationship between the projection point (eye-point) and it's distance to and size of a window we defined on the imaging plane.
- That window is *typically* what maps to our physical display (a window) but doesn't need to.

Camera Model

- We can change either or both
  - The position of our camera system in "space".
  - The parameters of our camera system.
    - Distance of projection point (eye) to image plane
    - Position of window on image plane
    - Size of window on image plane
  - All of these will effect the resulting image that is projected.

Camera Model

- Typically, the relationship would be something like this.



Next time…

- Get into the details
  - You should begin to get your development environment up and running with support for WebGL.
  - Consider implementing the fractal in Chapter 2.
  - Any recent laptop should be okay (2-3 years old)
  - Chrome or Firefox probably the best for WebGL
  - There are sites that will tell you if your browser supports webGL

Finally

- Sign up to the class site on Piazza
- https://piazza.com/ucla/winter2017/comsci174a

- Let us know your Github account name
- https://goo.gl/forms/fobVds2Qn1NzXkTF3