A tale of three UI frameworks

A decade of evolving developer and designer workflows in a game engine

unity

Who are we?

Adam Mechtley

Lead Developer

DOTS Physics & Rigging

Damian Campeanu

Developer

Editor & UI

What are we going to talk about?

- Brief overview of Unity Architecture
- IMGUI
- uGUI
- UI Toolkit
- Q&A

What is Unity and how do people make stuff with it?

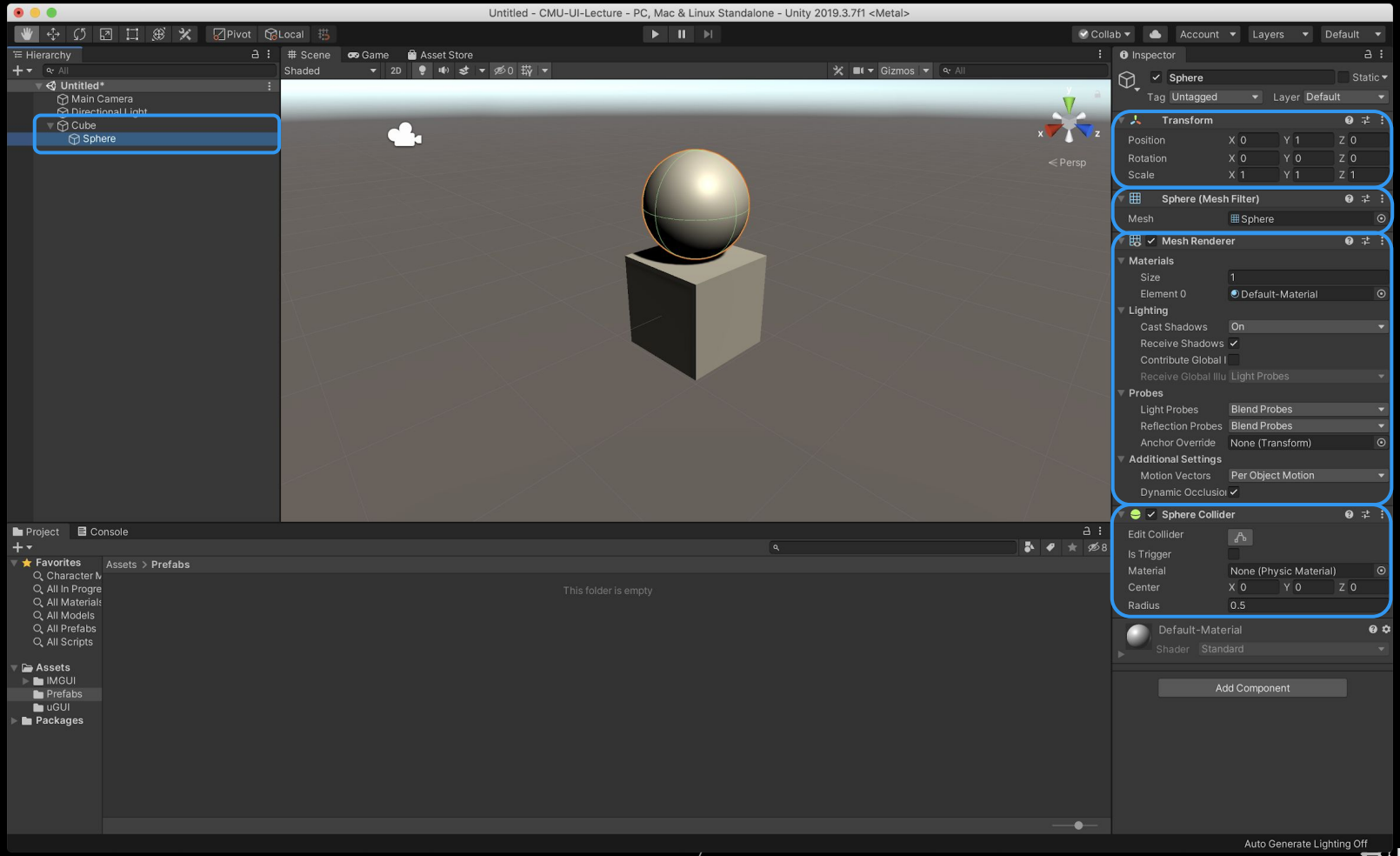
* Oversimplified version

More than just a game engine!

- Run-Time
  - Built-in libraries (input, animation, physics, UI, rendering, etc.)
  - Compatible with much of .NET ecosystem
- Editor
- Services
  - Analytics, live ops, etc.
- Asset Store
- Millions of users, hundreds of thousands active monthly

How do users make stuff with Unity?

- Create **GameObjects** and add **Components** to produce behavior
  - Create new Components via C#
- Create reusable **Prefabs** from GameObjects
  - Prefabs can be nested in each other with overrides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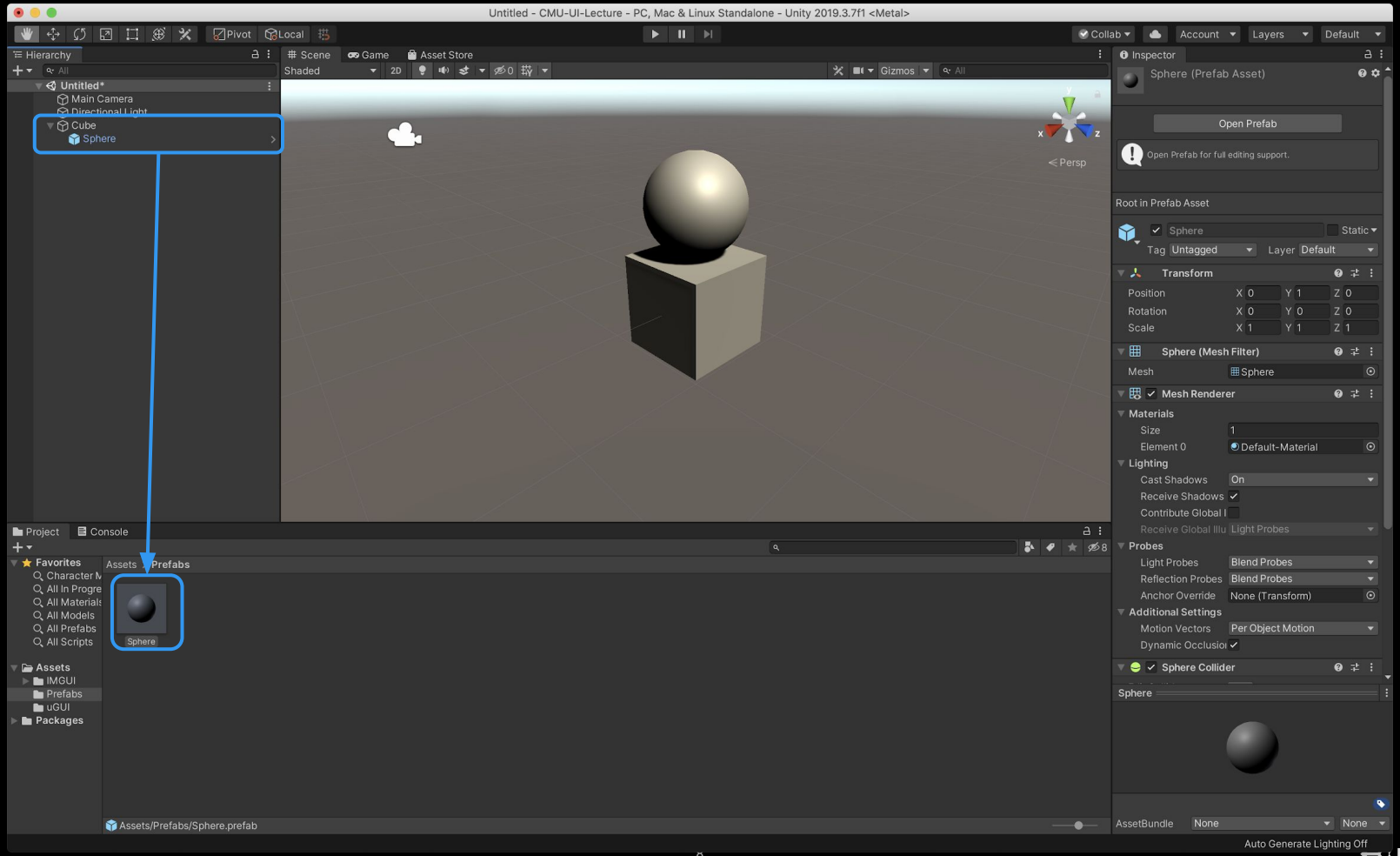
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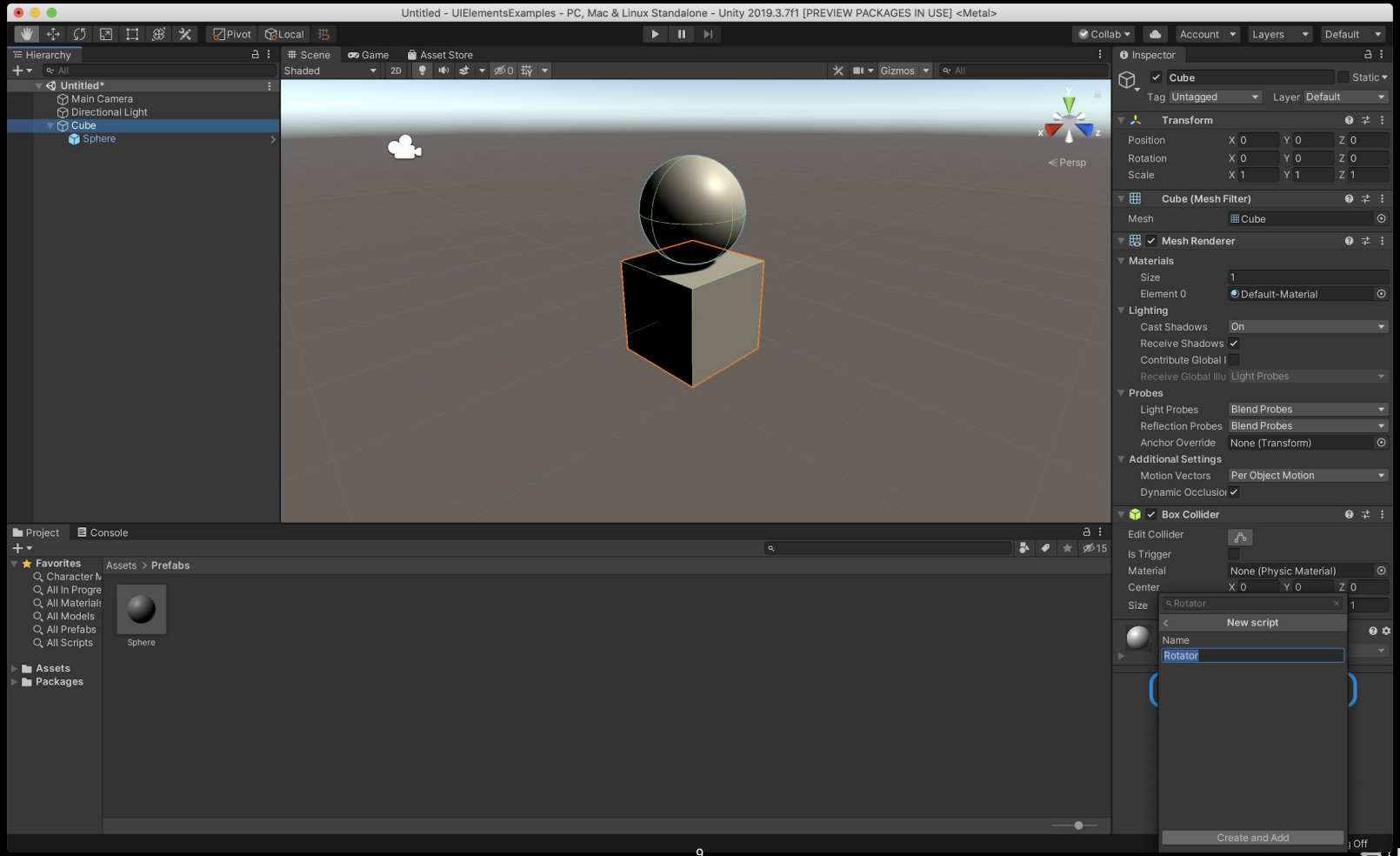
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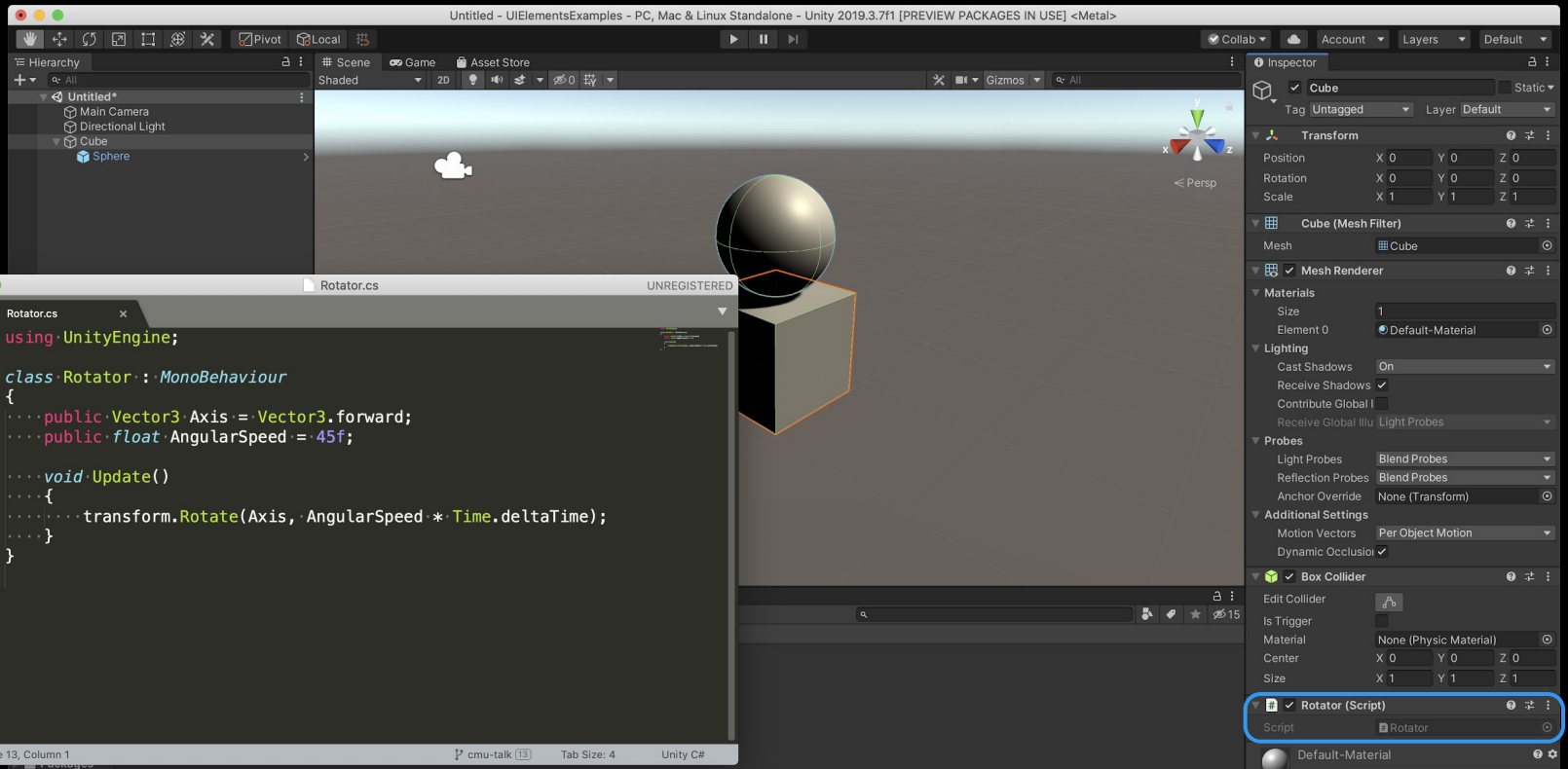
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using UnityEngine;
class Rotator : MonoBehaviour
{
public Vector3 Axis = Vector3.forward;
public float AngularSpeed = 45f;
void Update()
{
transform.Rotate(Axis, AngularSpeed * Time.deltaTime);
}
}
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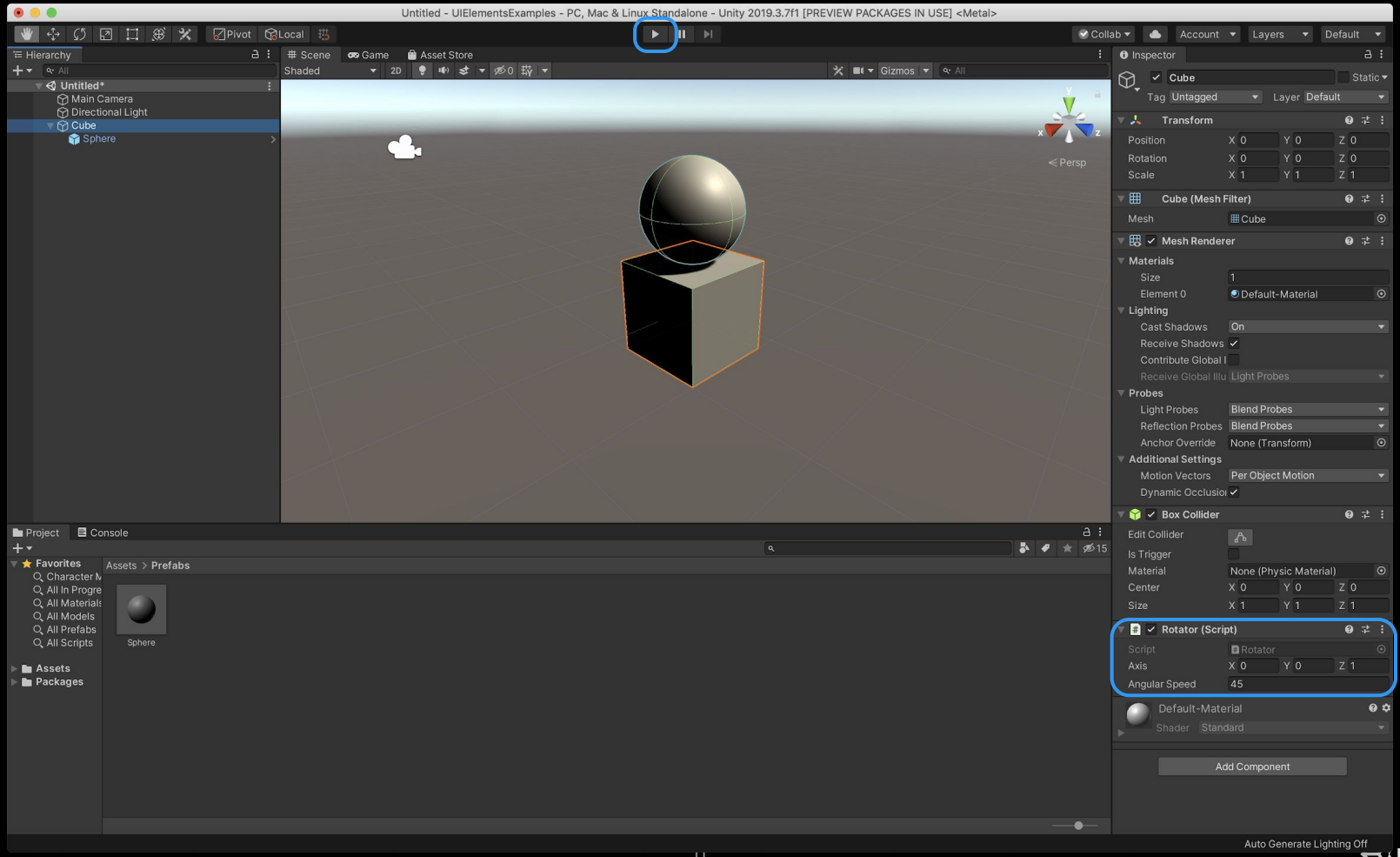
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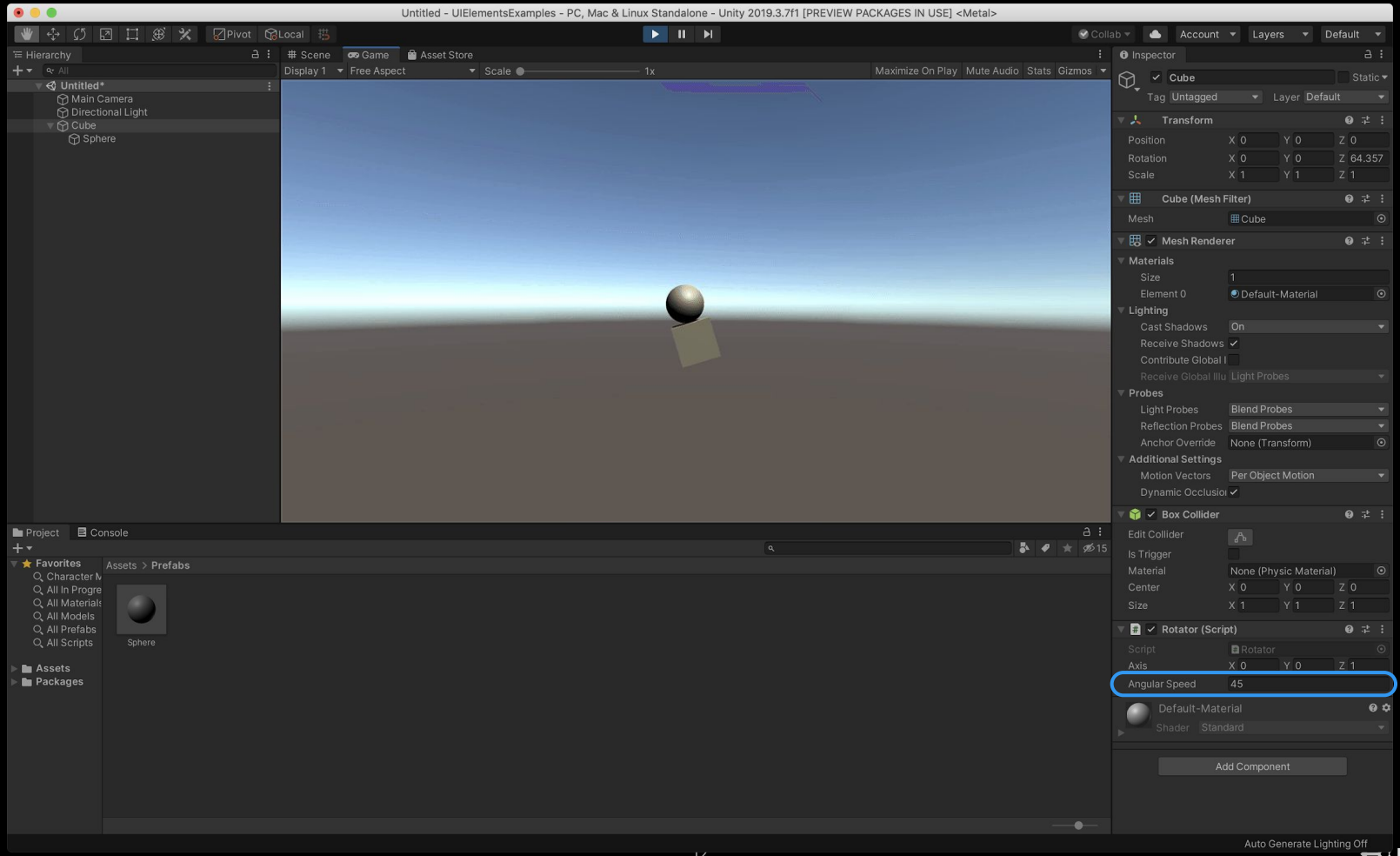
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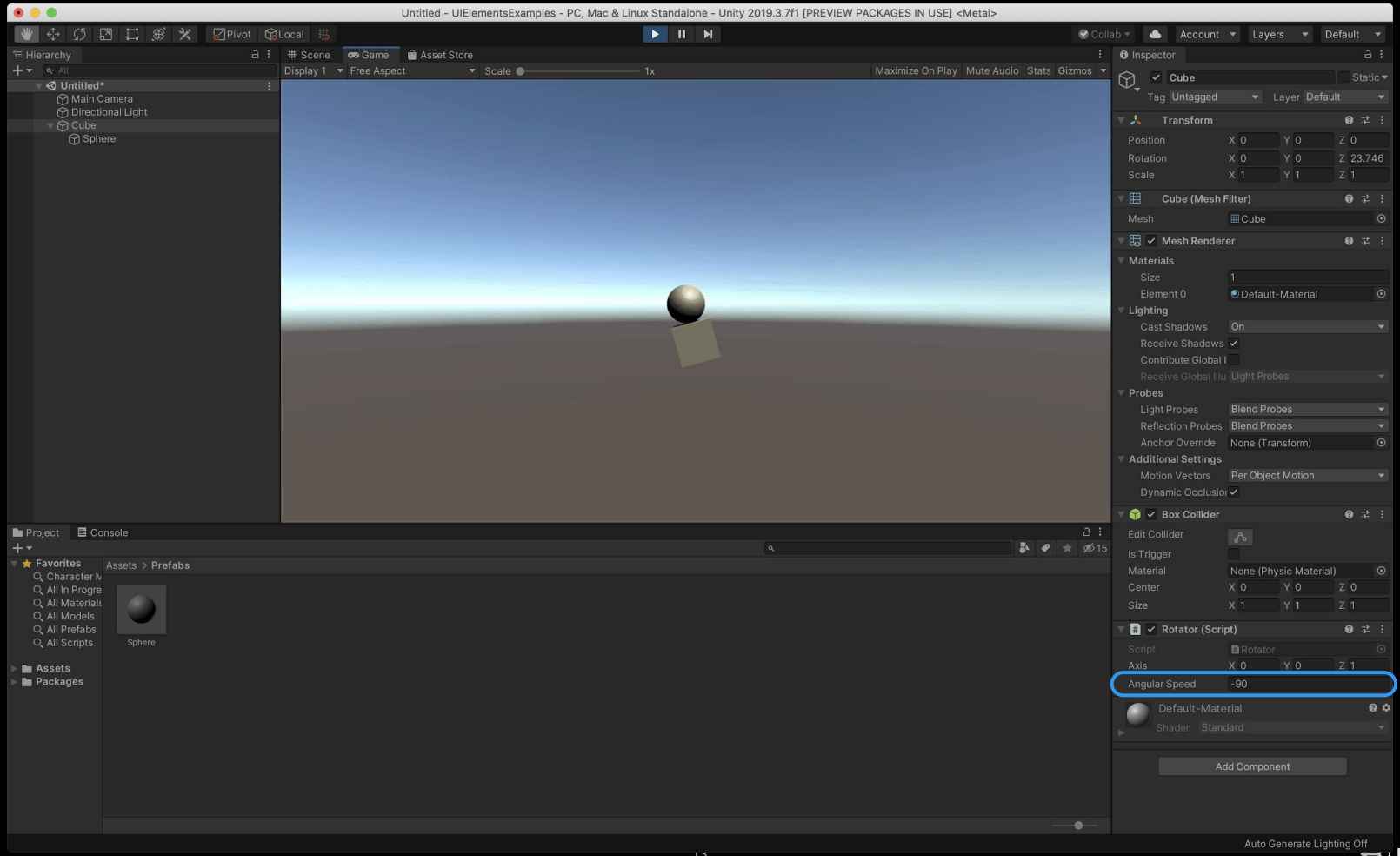
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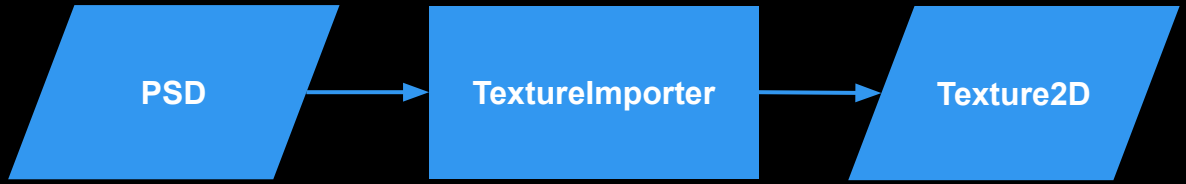
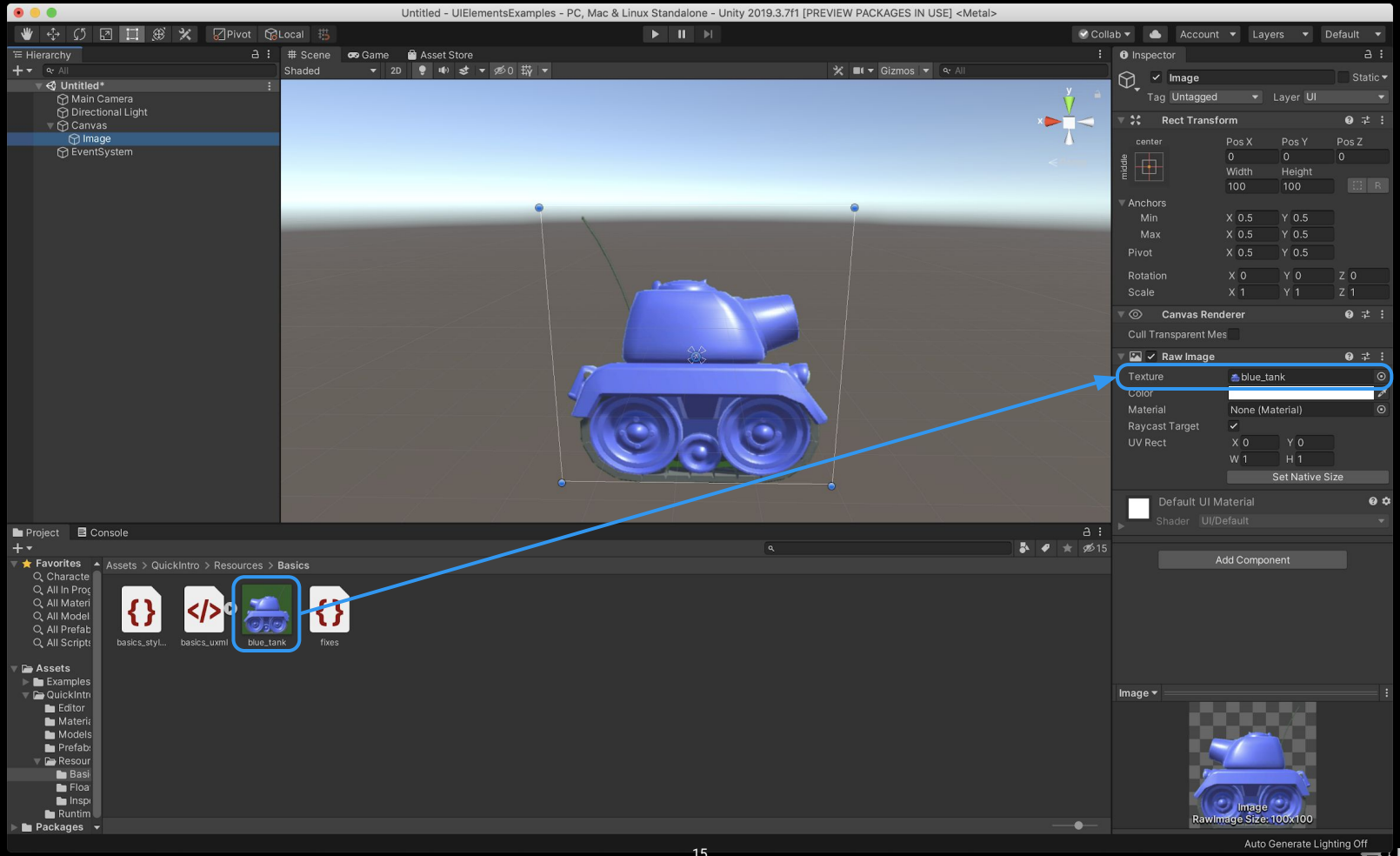
How do users create content for it?

- Save source file in project folder
- Built-in or custom asset importer generates artifact(s)

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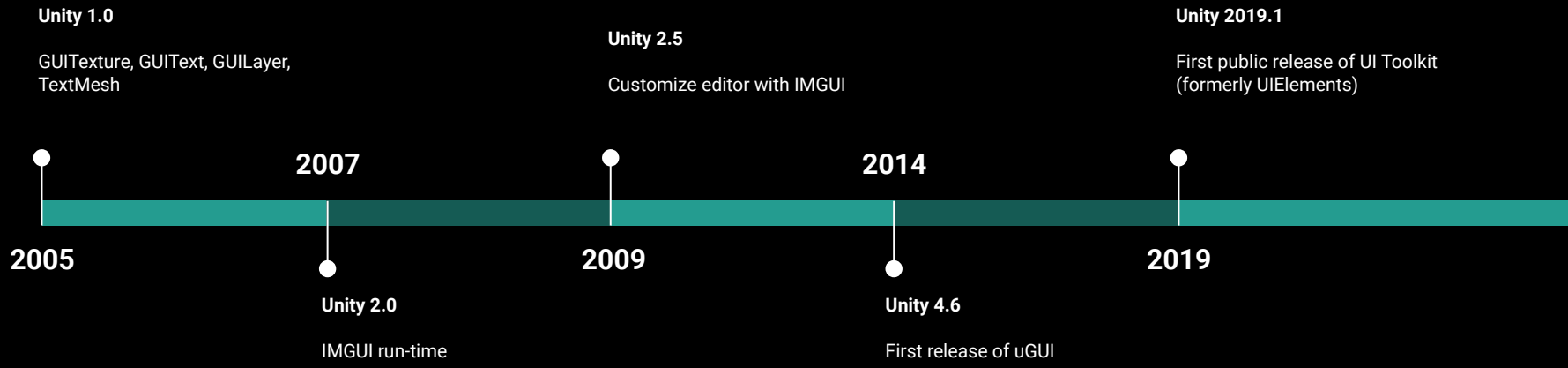
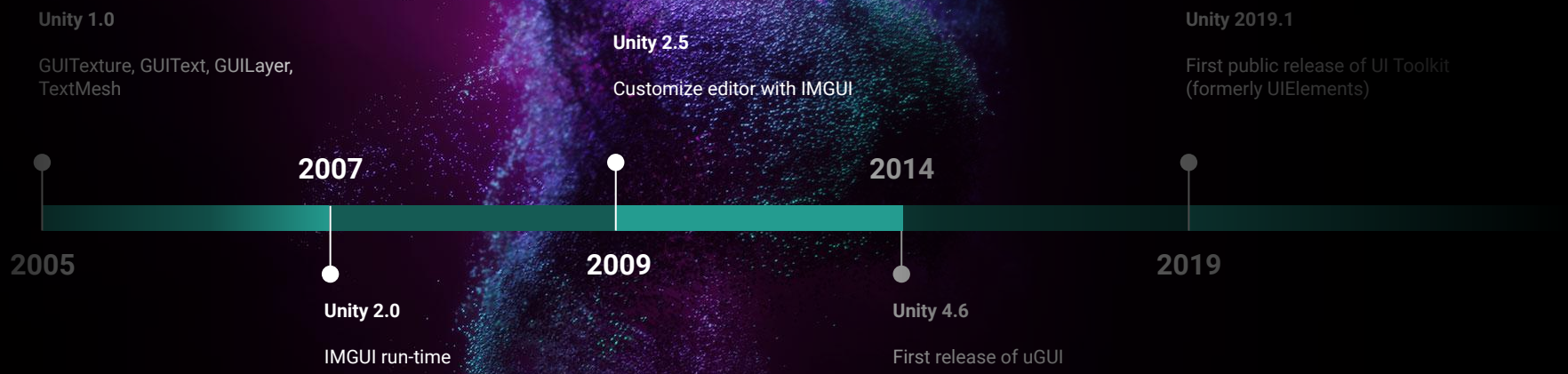
How do users create UI with it?



IMGUI

A simple UI framework for an ever-changing world



Design considerations

- Unity needs a UI framework! (both run-time and editor)
- Most Unity projects…
  - …are small web player experiences
  - …are created by small teams with few/broad role specializations
- Most game UI…
  - …communicates frequently updating values
  - …is non-diegetic overlays

IMGUI API

- `OnGUI()` callback
  - Event loop with `Event.current`
  - Call order determines event handling priority
- Library of static methods in `GUI` class for common functionality
  - `GUILayout` variants to assist with `Rect` calculations
  - Both run-time and editor-only variants for most types
- `GUIStyle` class
- `GUISkin` asset

API and Workflow Demo

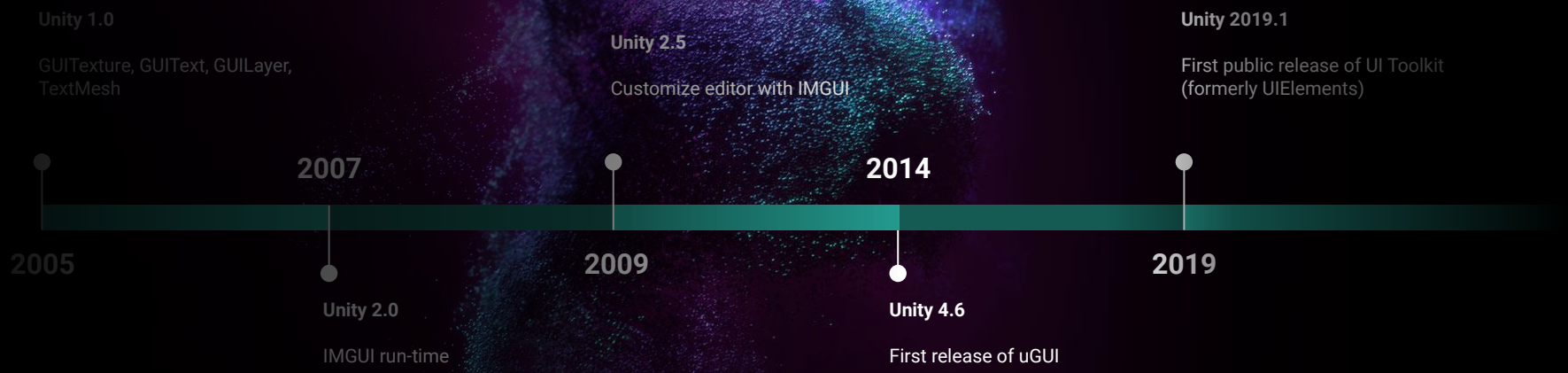
IMGUI advantages and disadvantages

+ Gathering and responding to input is trivial
+ Fast for programmers to prototype with
+ Works well for property grids
+ Simple API organization
+ Predictable performance

— But not very great performance
— Limited designer workflows
— No control over rendering pipeline
— Only supports non-diegetic UI
— Lots of manual work making new controls

uGUI

A framework for to make UI feel more like the rest of Unity



Design considerations

- Unity needs needs to empower designers to be productive more independently
- Most Unity projects…
  - …are created by teams with clearer role specializations
  - …run on mobile platforms where draw calls are expensive and display specifications vary wildly
- Most game UI…
  - …contains diegetic/spatial and non-diegetic elements
  - …is richly animated with effects

Fagerholt & Lorentzon (2009)

Exists in game fiction?	Visualized in 3D world? No	Visualized in 3D world? Yes
No	**Non-diegetic**	**Spatial**
Yes	**Meta**	**Diegetic**

uGUI API

- **UIBehaviour** base class inherits **MonoBehaviour**
  - Selectable, Graphic, etc sub-classes
- **Canvas** and **CanvasScalar** control rendering of hierarchies of elements
  - **RectTransform** (inherits **Transform**) use for layout
  - Most components draw **Sprite** assets
  - Set geometry, materials, etc. on child **CanvasRenderer**
- **StandaloneInputModule** and **EventSystem** gather and delegate input events
  - **BaseRaycaster** of some kind finds event handlers
  - **IPointerDownHandler**, **IPointerUpHandler**, **IDragHandler**, etc

API and Workflow Demo

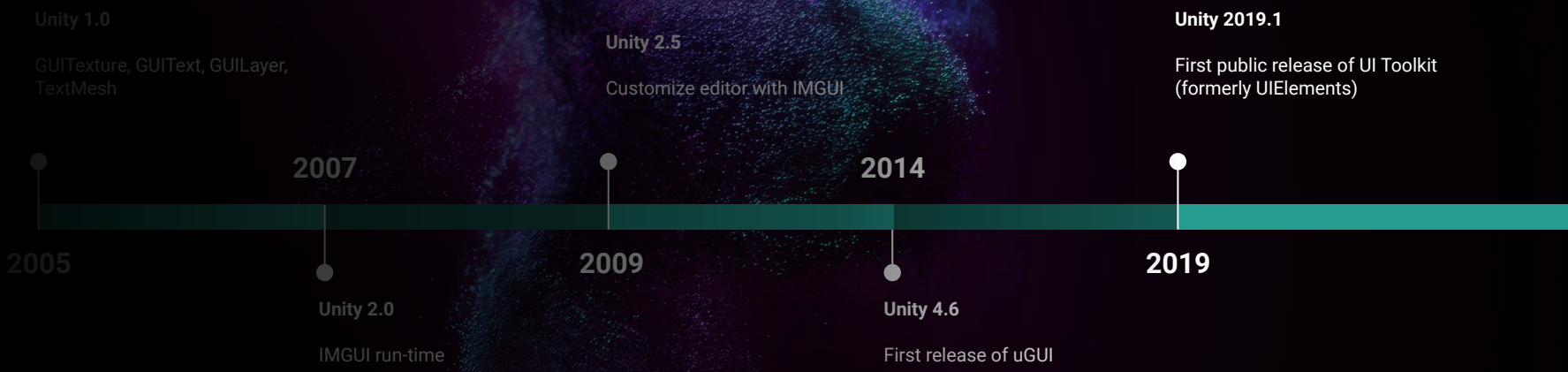
uGUI advantages and disadvantages

+ Designer workflows that fit with other Unity features (prefabs, animation, etc.)
+ Serializable event handlers
+ Automatic atlasing and scaling based on physical size, DPI, etc.
+ Diegetic UI
+ Common rendering pathway with everything else

— Performance overhead from GameObjects and Components
— Authoring data format hard to read and debug at a glance
— No centralized styling
— Canvases require specialized knowledge to optimize

UI Toolkit

A framework to make Unity feel more like the rest of the world



Generative Art — Made with Unity

unity

Design considerations

Collaboration
Different team members can work on different parts of the same UI.

Reusability
Share styles and templates within or across projects.

Iteration Speed
Quickly develop and validate UI for different contexts.

Extensibility
Customize and extend existing styles and templates or build custom ones.

Familiarity
UI authoring tools and workflows are familiar and easy to learn.

Rich Content
Build engaging UI that performs well as it scales.

UI Toolkit API

1

```
/* styles.uss */
.container { font-size: 40px; }
#random-explosion { color: blue; }
```

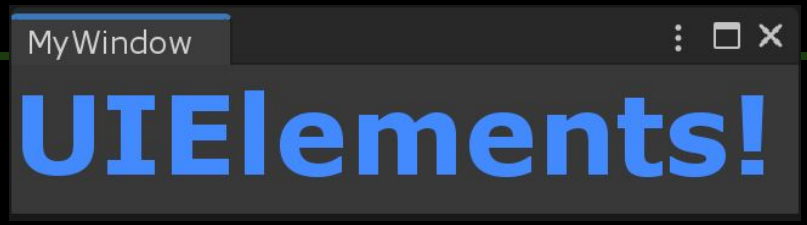
2

```
<!-- hierarchy.uxml -->
<UXML xmlns="UnityEngine.UIElements">
  <VisualElement class="container">
      <Style src="styles.uss" />
      <Label
          name="random-explosion"
          text="UIElements!" />
  </VisualElement>
</UXML>
```

3

```
// MyWindow.cs
void OnEnable() {
    var a = AssetDatabase.LoadAssetAtPath(
        "Assets/hierarchy.uxml");
    VisualElement row = a.CloneTree();
    var label =
        row.Q<Label>("random-explosion");
    label.RegisterCallback<MouseUpEvent>(
        evt => evt.StopPropagation());

    rootVisualElement.Add(row);
}
```



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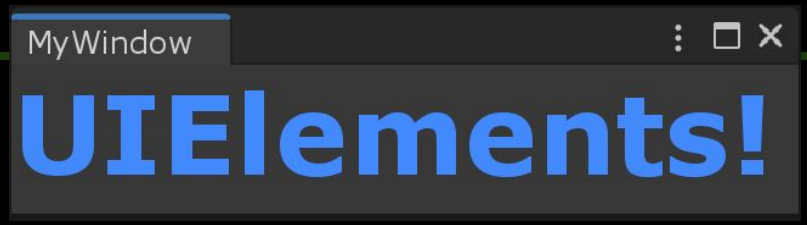

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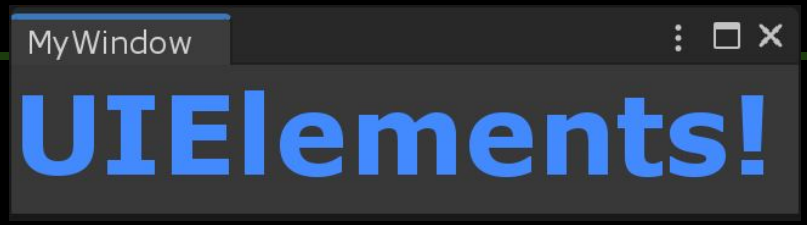

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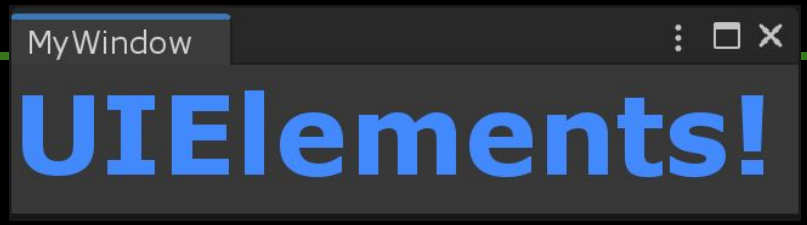


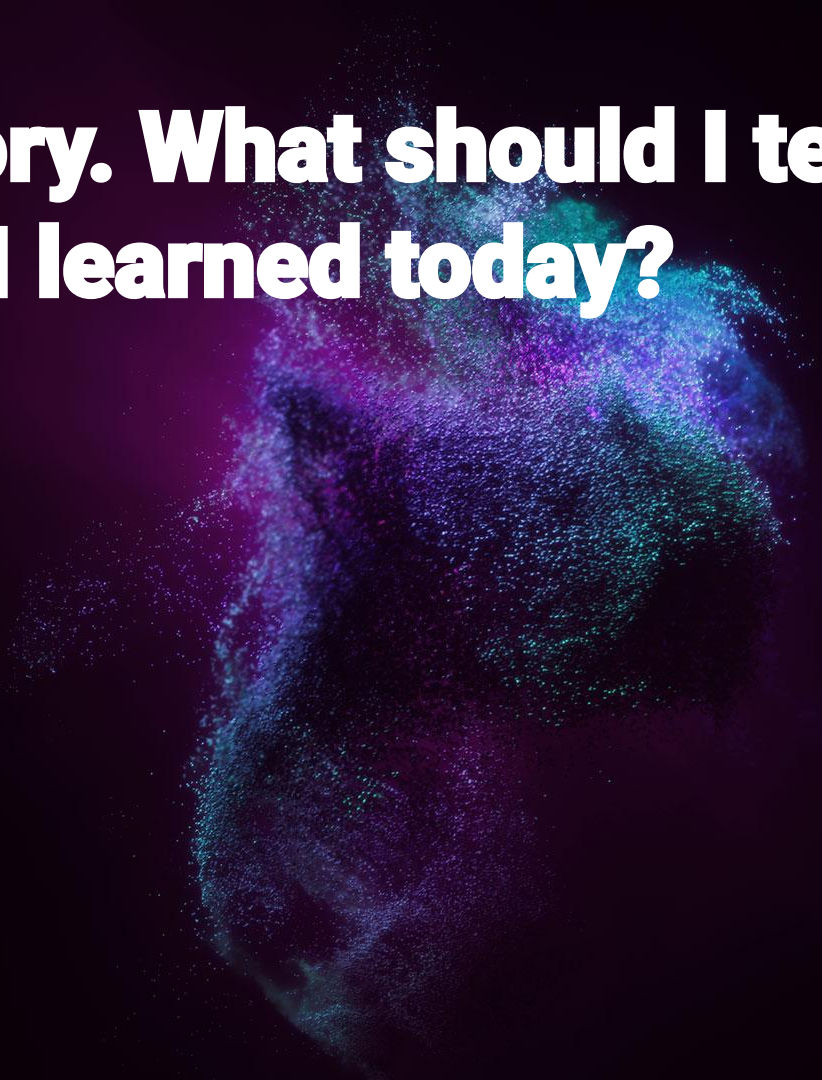
API and Workflow Demo

UI Toolkit advantages and disadvantages

+ Great performance for most use cases
+ Powerful automatic layouting via Flexbox
+ Centralized styling using standard paradigms (CSS)
+ Visual authoring without writing code
+ One API for both Editor and Runtime

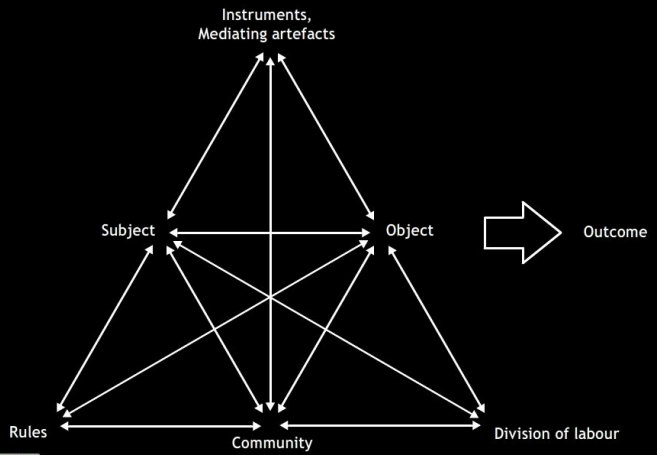
— Name-based handles can easily break
— Inefficient when lots of things are changing at once
— More complicated Event-based value bindings
— More complicated bindings to Unity objects and gameplay

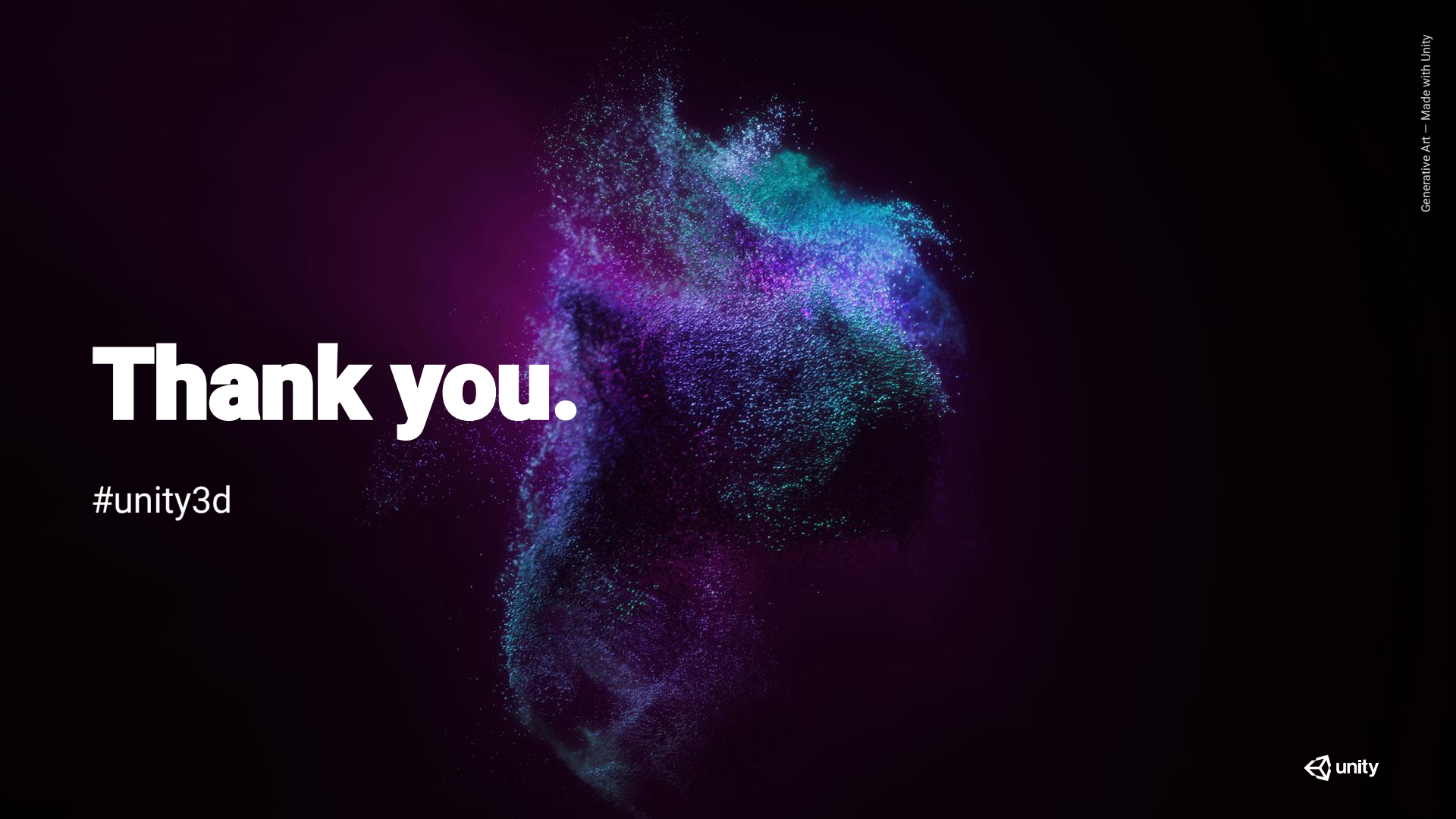
Cool story. What should I tell my friends I learned today?



Final thoughts

- Immediate-mode and retained-mode GUI each have strengths and disadvantages in different situations
- As the rest of the world evolves, so, too, must your API
  - Everything comes with a maintenance cost
- Reasonableness of API design decisions is very contextual
  - Aesthetic tastes of the historical moment
  - Technical requirements of target hardware
  - Tools ecosystem
- Design influences users' expressive capabilities




Thank you.
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