FROM CONCEPT TO PLAYABLE GAME

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Introduction to GAME DESIGN, PROTOTYPING, and DEVELOPMENT

Jeremy **GIBSON**

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This book is dedicated to:

My wife Melanie, the love of my life,
for her love, intellect, and support

My parents and sisters

And my many professors, colleagues, and students
who inspired me to write this book.

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FOREWORD

I have a theory about game designers and teachers. I think that, beneath the possible differences of our outer appearances, we're secretly the same; that many of the skills possessed by a good game designer are the same skills held by a great teacher. Have you ever had a teacher who held a class spellbound with puzzles and stories? Who showed you simple demonstrations of skills that were easy for you to understand and copy, but were difficult for you to master? Who gradually, cleverly, helped you put together pieces of information in your mind, maybe without your even realizing it, until one day your teacher was able to step aside and watch you do something amazing, something that you never would have thought was possible.

We video game designers spend a lot of our time finding ways to teach people the skills they need to play our games, while keeping them entertained at the same time. We sometimes don't want people to be aware that we're teaching them, though—the best tutorial levels that video games open with are usually the ones that simply seem like the beginning of a thrilling adventure. I was lucky to work at the award-winning game studio Naughty Dog for eight amazing years, where I was the Lead or Co-Lead Game Designer on all three PlayStation 3 games in the *Uncharted* series. Everyone at the studio was very happy with the sequence that opened our game *Uncharted 2: Among Thieves*. It effectively taught each player all the basic moves they would need to play the game, while keeping them on the edge of their seat because of the gripping predicament our hero Nathan Drake found himself in, dangling over the edge of a cliff in a ruined train carriage.

Video game designers do this kind of thing over and over again as they create digital adventures for us to play. Working on a sequence of player experiences like those found in the *Uncharted* games, I have to stay very focused on what the player has recently learned. I have to present my audience with interesting situations that use their new skills and that are easy enough that they won't get frustrated, but challenging enough that their interest will be held. To do this with complete strangers, through the channels of communication that a game provides—the graphics of the environments and the characters and objects within them, the sounds that the game makes, and the interactivity of the game's controls—is tremendously challenging. At the same time, it is one of the most rewarding things I know how to do.

Now that I've become a professor, teaching game design in a university setting, I've discovered firsthand just how many of the skills I developed as a game designer are useful in my teaching. I'm also discovering that teaching is just as rewarding as game design. So it came to me as no surprise when I discovered that Jeremy Gibson, the author of this book, is equally talented as a game designer and a teacher, as you're about to find out.

I first met Jeremy around ten years ago, at the annual Game Developers Conference in Northern California, and we immediately hit it off. He already had a successful career as a game developer, and his enthusiasm for game design struck a chord with me. As you'll see when you begin to read this book, he loves to talk about game design as a craft, a design practice and an emerging art. Jeremy and I stayed in touch over the years, as he went back to graduate school at Carnegie Mellon University's excellent Entertainment Technology Center to study under visionaries like Doctor Randy Pausch and Jesse Schell. Eventually, I came to know Jeremy as a professor and a colleague in the Interactive Media & Games Division of the School of Cinematic Arts at the University of Southern California—part of USC Games, the program in which I now teach.

In fact, I got to know Jeremy better than ever during his time at USC—and I did it by becoming his student. In order to acquire the skills that I needed to develop experimental research games as part of USC's Game Innovation Lab, I took one of Jeremy's classes, and his teaching transformed me from a Unity n00b with some basic programming experience into an experienced C# programmer with a strong set of skills in Unity, one of the world's most powerful, usable, adaptable game engines. Every single one of Jeremy's classes was not only packed with information about Unity and C#, but was also peppered with inspirational words of wisdom about game design and practical pieces of advice related to game development—everything from his thoughts about good "lerping," to great tips for time management and task prioritization, to the ways that game designers can use spreadsheets to make their games better. I graduated from Jeremy's class wishing that I could take it again, knowing that there was a huge amount more that I could learn from him.

So I was very happy when I heard that Jeremy was writing a book—and I became even happier when I read the volume that you now hold in your hands. The good news for both you and me is that Jeremy has loaded this book with everything that I wanted more of. I learned a lot in the game industry about best practices in game design, production, and development, and I'm happy to tell you that in this book, Jeremy does a wonderful job of summarizing those ways of making games that I've found work best. Within these pages, you'll find step-by-step tutorials and code examples that will make you a better game designer and developer in innumerable ways. While the exercises in this book might get complex—game design is among the most difficult things I know how to do—Jeremy won't ask you to do anything complicated without guiding you through it in clear, easy-to-follow language.

You'll also find history and theory in this book. Jeremy has been thinking deeply about game design for a long time and is very well-read on the subject. In the first part of this volume, you'll find an extraordinarily wide and deep survey of the state-of-the-art in game design theory, along with Jeremy's unique and strongly developed synthesis of the very best ideas he's encountered on his game design travels. Jeremy supports his discussion with interesting historical anecdotes and fascinating glimpses of the long traditions of play in human culture, all of which help to frame his conversation in valuable and progressive ways. He continually pushes you to question your assumptions about games, and to think beyond the console, the controller, the screen and the speakers, in ways that might just spur a whole new generation of game innovators.

Jeremy Gibson has moved on from USC, and now teaches at the University of Michigan Ann Arbor, and I'm very happy for the generations of U-M students that he'll lead to new understandings of the craft of game design in the coming years. This spring, when Jeremy walked into the restaurant at the annual GDC alumni dinner hosted by the USC Games program, the room full of our current and former students came alive with whoops and cheers and moments later broke out into applause. That tells you a lot about what Jeremy Gibson is like as a teacher. You're lucky that, thanks to this book, he can now be your teacher too.

The world of game design and development is changing at a rapid rate. You can be part of this wonderful world—a world unlike any other I know, and which I love with all my heart. You can use the skills you learn through reading this book to develop new prototypes for new kinds of games, and in doing so you might eventually create whole new genres of games, in expressive new styles, which appeal to new markets. Some of tomorrow's stars of game design are currently learning to design and program, in homes and schools all around the world. If you make good use of this book, by following the advice and doing the exercises you find in here, it might just help your chances of creating a modern game design classic.

Good luck, and have fun!

Richard Lemarchand
Associate Professor, USC Games

PREFACE

Welcome to *Introduction to Game Design, Prototyping, and Development*. This book is based on my work over many years as both a professional game designer and a professor of game design at several universities, including the Interactive Media and Games Division at the University of Southern California and the Department of Electrical Engineering and Computer Science at the University of Michigan Ann Arbor.

This preface introduces you to the purpose, scope, and approach of this book.

The Purpose of This Book

My goal in this book is quite simple: I want to give you all the tools and knowledge you need to get started down the path to being a successful game designer and prototyper. This book is the distillation of as much knowledge as I can cram into it to help you toward that goal. Unlike most books out there, this book combines the disciplines of game design and digital development (that is, computer programming) and wraps them both in the essential practice of iterative prototyping. The emergence of advanced, yet approachable, game development engines such as Unity has made it easier than ever before to create playable prototypes that express your game design concepts to others, and the ability to do so will make you a much more skilled (and employable) game designer.

The book is divided into four parts:

Part I: Game Design and Paper Prototyping

The first part of the book starts by exploring various theories of game design and the analytical frameworks for game design that have been proposed by several earlier books. This section then describes the *Layered Tetrad* as a way of combining and expanding on many of the best features of these earlier theories. The Layered Tetrad is explored in depth as it relates to various decisions that you must make as a designer of interactive experiences. This part also covers information about the interesting challenges of different game design disciplines; describes the process of paper prototyping, testing, and iteration; and gives you concrete information to help you become a better designer.

Part II: Digital Prototyping

The second part teaches you how to program in the C# language (pronounced "see-sharp"). This part draws upon my many years of experience as a professor teaching nontechnical students how to express their game design ideas through digital code. If you have no prior knowledge or experience with programming or development, this part is designed for you. However, even if you do have some programming experience, you might want to take a look at this part to learn a few new tricks or get a refresher on some approaches.

Part III: Game Prototype Examples and Tutorials

The third part of the book encompasses several different tutorials, each of which guides you through the development of a prototype for a specific style of game. The purpose of this part is twofold: It reveals some best practices for rapid game prototyping by showing you how I personally approach prototypes for various kinds of games, and it provides you with several basic foundations on which to build your own games in the future. Most other books on the market that attempt to teach Unity (our game development environment) do so by taking the reader through a single, monolithic tutorial that is hundreds of pages long. In contrast, this book takes you through several much smaller tutorials. The final products of these tutorials are necessarily less robust than those found in some other books, but it is my belief that the variety of projects in this book will better prepare you for creating your own projects in the future.

Part IV: Appendices

This book has several important appendices that merit mention here. Rather than repeat information throughout the book or require you to go hunting through various chapters for it, any piece of information that is referenced several times in the book or that I think you would be likely to want to reference later (after you've finished reading the book once) is placed in the appendices. Appendix A is just a quick step-by-step introduction to the initial creation process for a game project in Unity. The second and longest appendix is Appendix B, "Useful Concepts." Though it has a rather lackluster name, this is the portion of the book that I believe you will return to most often in the years following your initial read through the book. "Useful Concepts" is a collection of several go-to technologies and strategies that I use constantly in my personal game prototyping process, and I think you'll find a great deal of it to be very useful. The third and final appendix is a list of good online references where you can find answers to questions not covered in this book. It is often difficult to know the right places to look for help online; this appendix lists those that I personally turn to most often.

There Are Other Books Out There

As a designer or creator of any kind, I think that it's absolutely essential to acknowledge those on whose shoulders you stand. There have been many books written on games and game design, and the few that I list here are those that have had the most profound effect on either my process or my thinking about game design. You will see these books referenced many times throughout this text, and I encourage you to read as many of them as possible.

Game Design Workshop by Tracy Fullerton

Initially penned by Tracy Fullerton, Chris Swain, and Steven S. Hoffman, *Game Design Workshop* is now in its third edition. More than any other text, this is the book that I turn to for advice on game design. This book was initially based on the Game Design Workshop class that Tracy and Chris taught at the University of Southern California, a class that formed the foundation for the entire games program at USC (and a class that I myself taught there from 2009–2013). The USC Interactive Media and Games graduate program has been named the number one school for game design in North America by Princeton Review every year that they have been ranking game programs, and the Game Design Workshop book and class were the foundation for that success.

Unlike many other books that speak volumes of theory about games, Tracy's book maintains a laser focus on information that helps budding designers improve their craft. I taught from this book for many years (even before I started working at USC), and I believe that if you actually attempt all the exercises listed in the book, you can't help but have a pretty good paper game at the end.

> Fullerton, Tracy, *Game Design Workshop: A Playcentric Approach to Creating Innovative Games,* 3rd ed. (Boca Raton, FL: CRC Press, 2014)

The Art of Game Design by Jesse Schell

Jesse Schell was one of my professors at Carnegie Mellon University and is a fantastic game designer with a background in theme park design gained from years working for Walt Disney Imagineering. Jesse's book is a favorite of many working designers because it approaches game design as a discipline to be examined through 100 different lenses that are revealed throughout the book. Jesse's book is a very entertaining read and broaches several topics not covered in this book.

> Jesse Schell, *The Art of Game Design: A Book of Lenses* (Boca Raton, FL: CRC Press, 2008)

The Grasshopper by Bernard Suits

While not actually a book on game design at all, *The Grasshopper* is an excellent exploration of the definition of the word *game*. Presented in a style reminiscent of the Socratic method, the book presents its definition of game very early in the text as the Grasshopper (from Aesop's fable *The Ant and the Grasshopper*) gives his definition on his deathbed, and his disciples spend the remainder of the book attempting to critique and understand this definition. This book also explores the question of the place of games and play in society.

> Bernard Suits, *The Grasshopper: Games, Life and Utopia* (Peterborough, Ontario: Broadview Press, 2005)

Game Design Theory by Keith Burgun

In this book, Burgun explores what he believes are faults in the current state of game design and development and proposes a much narrower definition of *game* than does Suits. Burgun's goal in writing this text was to be provocative and to push the discussion of game design theory forward. While largely negative in tone, Burgun's text raises a number of interesting points, and reacting to it helped me to refine my personal understanding of game design.

> Keith Burgun, *Game Design Theory: A New Philosophy for Understanding Games* (Boca Raton, FL: A K Peters/CRC Press, 2013)

Imaginary Games by Chris Bateman

Bateman uses this book to argue that games are a legitimate medium for scholarly study. He pulls from several scholarly, practical, and philosophical sources; and his discussions of books like *Homo Ludens* by Johan Huizinga, *Man, Play, and Games* by Roger Caillois, and the paper "The Game Game" by Mary Midgley are both smart and accessible.

> Chris Bateman, *Imaginary Games* (Washington, USA: Zero Books, 2011)

Level Up! by Scott Rogers

Rogers distills his knowledge from many years in the trenches of game development into a book that is fun, approachable, and very practical. When he and I co-taught a level design class, this was the textbook that we used. Rogers is also a comic book artist, and his book is full of humorous and helpful illustrations that drive home the concepts of level, character, narrative, and many other aspects of design.

> Scott Rogers, *Level up!: The Guide to Great Video Game Design* (Chichester, UK: Wiley, 2010)

Our Digital Prototyping Environment: Unity and C#

All the digital game examples in this book are based on the Unity Game Engine and the C# programming language. I have taught students to develop digital games and interactive experiences for more than a decade, and in my experience, Unity is—by far—the best environment that I have found for learning to develop games. I have also found that C# is the best initial language for game prototypers to learn. Some other tools out there are easier to learn and require no real programming (Game Maker and Game Salad are two examples), but Unity allows you much more flexibility and performance in a package that is basically free (the free version of Unity includes nearly all the capabilities of the paid version, and it is the version used throughout this book). If you want to actually learn to program games, Unity is the engine you want to use.

Similarly, some programming languages are a little more approachable than C#. In the past, I have taught my students both ActionScript and JavaScript. However, C# is the one language I have used that continually impresses me with its flexibility and feature set. Learning C# means learning not only programming but also good programming practices. Languages such as JavaScript allow a lot of sloppy behaviors that I have found actually lead to slower development. C# keeps you honest (via things like strongly typed variables), and that honesty will not only make you a better programmer but will also result in your being able to code more quickly (for example, strong variable typing enables very robust code hinting and auto-completion, which makes coding faster and more accurate).

Who This Book Is For

There are many books about game design, and there are many books about programming. This book seeks to fill the gap between the two. As game development technologies like Unity become more ubiquitous, it is increasingly important that game designers have the ability to sketch their design ideas not only on paper but also through working digital prototypes. This book exists to help you learn to do just that:

- **If you're interested in game design but have never programmed,** this book is perfect for you. Part I introduces you to several practical theories of game design and presents you with the practices that can help you develop and refine your design ideas. Part II teaches you how to program from nothing to understanding object-oriented class hierarchies. Since I became a college professor, the majority of my classes have focused on teaching nonprogrammers how to program games. I have distilled all of my experience doing so into Part II of this book. Part III takes you through the process of developing eight different game prototypes across several different game genres. Each demonstrates fast methods to get from concept to working digital prototype. Lastly, the appendices will explain specific game development and programming concepts in-depth and guide you to resources to learn more once you've finished the book. This in-depth content was moved to Appendix B, "Useful Concepts," so that you could continue to use that section of the book as a reference in the years to come.

- **If you're a programmer who is interested in game design,** Parts I and III of this book will be of most interest to you. Part I introduces you to several practical theories for game design and presents you with the practices that can help you develop and refine your design ideas. You can skim Part II, which introduces C# and how it is used in Unity. If you are familiar with other programming languages, C# looks like C++ but has the advanced features of Java. Part III takes you through the process of developing eight different game prototypes across several different game genres. Game development in Unity is very different from what you may be used to from other game engines. Many elements of development are taken care of outside of the code. Each prototype will demonstrate the style of development that works best in Unity to get from concept to working digital prototype quickly. You will also want to look carefully at Appendix B, which is full of detailed information about various development concepts and is arranged as a reference that you can return to later.

Conventions

This book maintains several writing conventions to help make the text more easily understandable.

Any place that specific button names, menu commands, or other multi-word nouns are introduced in the text, they will be listed in *italics*. This includes terms like the *Main Camera* Game Object. An example menu command is *Edit* > *Project Settings* > *Physics*, which would instruct you to select the *Edit* menu from the menu bar, choose the *Project Settings* sub-menu, and then select *Physics*.

Book Elements

The book includes several different types of asides that feature useful or important information that does not fit in the flow of the regular body text.

note

Callouts in this format are for information that is useful but not critical. Information in notes will often be an interesting aside to the main text that provides a little bit more info about the topic.

tip

This element provides additional information that is related to the book content and can help you as you explore the concepts in the book.

warning

BE CAREFUL Warnings cover information about things that you need to be aware of to avoid mistakes or other pitfalls.

SIDEBAR

The sidebar is for discussions of longer topics that are important to the text but should be considered separately from it.

Code

Several conventions apply to the code samples in this book. When specific elements from the code listing are placed in regular paragraph text, they appear in a `monospaced` font. The variable `variableOnNewLine` from the following code listing is an example of this.

Code listings also utilize a monospaced font and appear as follows:

```
public class SampleClass {
    public GameObject        variableOnExistingLine;                      // 1
    public GameObject        variableOnNewLine;                           // 2
}
```

1 Code listings are often annotated; in this case, additional information about the line marked with `// 1` would appear in this first annotation.

2 Some code listings will be expansions on code that you've already written or that already exists in the C# script file for another reason. In this case, the old lines will be at `normal weight`, and the new lines will be at **`bold weight`**.

Note that occasionally lines of code in the chapters are too long to fit on the printed page. Where that occurs, a code-continuation arrow (➥) has been used to mark the continuation. For example:

```
21          jaggedList.Add ( new List<string>( new string[] {"complex",
                  ➥"initialization"} ) );
```

Most of the code listings in the first two parts of the book will include line numbers (as seen in the preceding listing). You do not need to type the line numbers when entering the code into MonoDevelop (it will automatically number all lines). In the final part of the book, there are no line numbers due to the size of the code listings.

Book Website

The website for this book includes all of the files referenced in the chapters, lecturer notes, and finished versions of each tutorial prototype. It is available at **http://book.prototools.net**.

ACKNOWLEDGMENTS

A tremendous number of people deserve to be thanked here. First and foremost, I want to thank my wife, Melanie, whose help and feedback on my chapters throughout the entire process improved the book tremendously. I also want to thank my family for their many years of support, with special thanks to my father for teaching me how to program as a child.

As a new author, there were several people at Pearson who provided support to me and shepherded me through this process. Chief among them were Chris Zahn, Laura Lewin, Olivia Basegio, Elaine Wiley, and Keith Cline who each demonstrated laudable patience in working with me. I also had the support of some fantastic technical reviewers: Marc Destefano, Charles Duba, and Margaret Moser. Their keen eyes and minds found many places in the original text that could be clarified or improved.

I would also like to thank all the educators who have taught me and worked as my colleagues. Special thanks go to Dr. Randy Pausch and Jesse Schell. Though I had worked as a professor and game designer before meeting them, they each had a profound effect on my understanding of design and education. I also owe tremendous thanks to Tracy Fullerton, Mark Bolas, and Scott Fisher, who were friends and mentors to me in the years I taught at the University of Southern California's Interactive Media and Games Division. There were also many other brilliant faculty and friends at USC who helped me to flesh out the ideas in this book, including Adam Liszkiewicz, William Huber, Richard Lemarchand, Scott Rogers, Vincent Diamante, Sam Roberts, and Logan Ver Hoef.

Many of my friends in the industry have also helped me by giving me suggestions for the book and feedback on the ideas presented therein. These included Michael Sellers, Nicholas Fortugno, Jenova Chen, Zac Pavlov, Joseph Stevens, and many others.

Thanks as well to all the fantastic students whom I have taught over the past decade. It is you who inspired me to want to write this book and who convinced me that there was something important and different about the way that I was teaching game development. Every day that I teach, I find myself inspired and invigorated by your creativity, intelligence, and passion.

Finally, I would like to thank you. Thank you for purchasing this book and for your interest in developing games. I hope that this book helps you get started, and I would love to see what you make with the knowledge you gain here.

ABOUT THE AUTHOR

Jeremy Gibson is a lecturer teaching computer game design for the Electrical Engineering and Computer Science department at the University of Michigan Ann Arbor and is the founder of ExNinja Interactive, LLC. From 2009 to 2013, he was an Assistant Professor teaching game design and protyping for the Interactive Media and Games Division of the University of Southern California's School of Cinematic Arts, which was the number one game design school in North America throughout his tenure there. Jeremy serves the IndieCade independent game festival as the Chair for Education and Advancement, where he is responsible for the IndieXchange and GameU conference tracks, and he has spoken at the Game Developers Conference every year since 2009.

Jeremy earned a Master of Entertainment Technology degree from Carnegie Mellon University's Entertainment Technology Center in 2007 and a Bachelor of Science degree in Radio, Television, and Film from the University of Texas at Austin in 1999. Jeremy has worked as a programmer and prototyper for companies such as Human Code and frog design, has taught classes for Great Northern Way Campus (in Vancouver, BC), Texas State University, the Art Institute of Pittsburgh, Austin Community College, and the University of Texas at Austin, and has worked for Walt Disney Imagineering, Maxis, and Electronic Arts/Pogo.com, among others. While in graduate school, his team created the game *Skyrates*, which won the Silver Gleemax Award at the 2008 Independent Games Festival. Jeremy also apparently has the distinction of being the first person to ever teach game design in Costa Rica.

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CHAPTER 16

INTRODUCING OUR DEVELOPMENT ENVIRONMENT: UNITY

This is the start of your programming adventure.

In this chapter, you download Unity, the game development environment that you will use throughout the rest of this book. We talk about why Unity is a fantastic game development tool for any budding game designer or developer and why we've chosen C# as the language for you to learn.

You also take a look at the sample project that ships with Unity, learn about the various window panes in the Unity interface, and move these panes into a logical arrangement that will match the examples you see in the rest of the book.

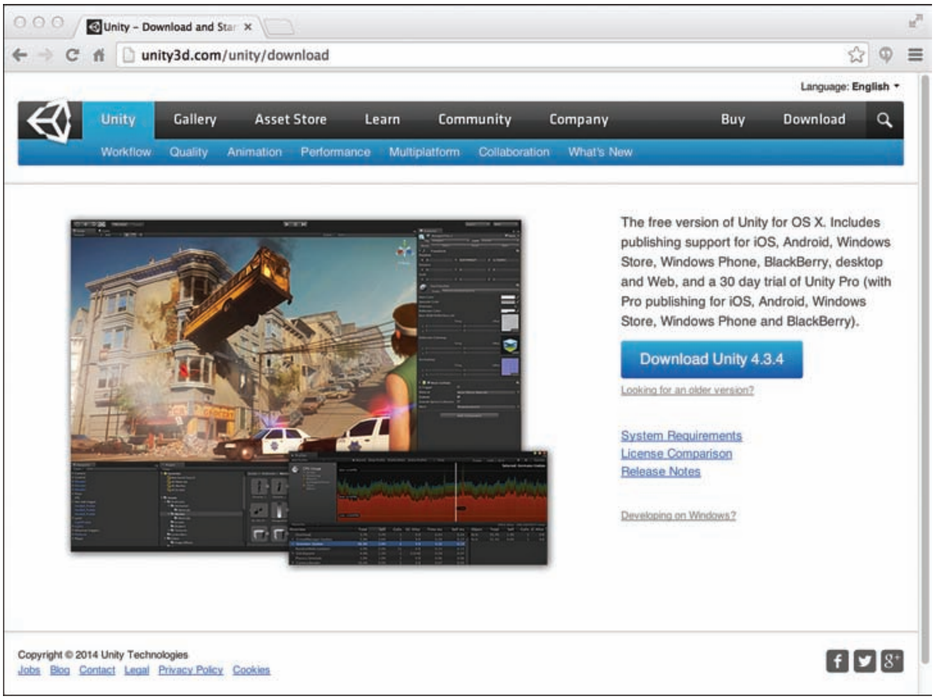
Downloading Unity

First things first, let's start downloading Unity. The Unity installer is over 1 GB in size, so depending on your Internet speed, this could take anywhere from a few minutes to a couple of hours. After you've gotten this process started, we can move on to talking about Unity.

As of this writing, the latest major version of Unity is Unity 4. Because Unity is under constant development, the current minor version should be something like 4.x.y, with the *x* and *y* being sub-version numbers. Regardless of version, Unity is always available for free from Unity's official website:

http://unity3d.com/unity/download

This should take you to a page that provides the latest download link for your system (see Figure 16.1). Unity is available for both PC and OS X, and it is nearly identical on both platforms.



The free version of Unity for OS X. Includes publishing support for iOS, Android, Windows Store, Windows Phone, BlackBerry, desktop and Web, and a 30 day trial of Unity Pro (with Pro publishing for iOS, Android, Windows Store, Windows Phone and BlackBerry).

Copyright © 2014 Unity Technologies

Figure 16.1 The web page to download Unity

tip

Unity is free, but you will still need to acquire a license, and this requires that you have an available Internet connection the first time that you run the application.

Introducing Our Development Environment

Before you can begin prototyping in earnest, you first need to become familiar with Unity, our chosen development environment. Unity itself can really be thought of as a synthesis program; while you will be bringing all the elements of your game prototypes together in Unity, the actual production of the assets will largely be done in other programs. You will program in MonoDevelop; model and texture in a 3D modeling program like Maya, Autodesk 3ds Max, or Blender; edit images in a photo editor such as Photoshop or GIMP; and edit sound in an audio program such as Pro Tools or Audacity. Because a large section of this book is about programming and learning to program in C# (pronounced "see-sharp"), you'll be spending most of the time with tutorials using MonoDevelop, but it's still critically important to understand how to use Unity and how to effectively set up your Unity environment.

Why Choose Unity?

There are many game development engines out there, but we've chosen to focus on Unity for several reasons:

- **Unity is free:** With the free version of Unity, you can create and sell games that run on OS X, PC, the Web, Linux, iOS, Android, BlackBerry, Windows Phone, Windows Store, and more. While the Pro version of Unity includes a few additional useful features, for a game designer just learning to prototype, the free version is really all that you need. The Pro version normally costs $1,500 (or $75/month), but if you're a student, a one-year license for Unity Pro is about ten times less!

tip

STUDENT PRICING If you are a student, you can purchase a 1-year educational license for Unity Pro at a tremendous discount (about $150 instead of $1,500). This license does prevent you from being able to sell your game directly to players, but it lets you use the full power of Unity Pro to develop your game and make excellent portfolio pieces. After you're done developing, if you know you've got a hit on your hands, you can purchase the commercial version of Pro before attempting to sell your game. Unity has also recently added Pro student licenses that do allow you to sell your games, but those have a higher cost.

To find the latest student pricing for Unity, I recommend searching the Web for "unity educational student pricing." That will make sure that you're looking at the latest.

- **Write once, deploy anywhere:** The free version of Unity can build applications for OS X, PC, the Web, Linux, iOS, Android, BlackBerry, Windows Phone, Windows Store, and more, all from the same code and files. This kind of flexibility is at the core of Unity; in fact, it's what the product and company are named for. There are also paid extensions to Unity Pro that professionals can use to create games for the PlayStation 3, Xbox 360, and several other game consoles.

- **Great support:** In addition to excellent documentation, Unity has an incredibly active and supportive development community. Hundreds of thousands of developers are using Unity, and many of them contribute to the discussions on Unity forums across the web.
- **It's awesome!:** My students and I have joked that Unity has a "make awesome" button. Although this is not strictly true, there are several phenomenal features built in to Unity that will make your games both play and look better by simply checking an option box. Unity engineers have already handled a lot of the difficult game programming tasks for you. Collision detection, physics simulation, pathfinding, particle systems, draw call batching, shaders, the game loop, and many other tough coding issues are all included. All you need to do is make a game that takes advantage of them!

Why Choose C#?

Within Unity, you have the choice to use any of three programming languages: UnityScript, C#, or Boo. Very, very few people actually use Boo, so you're really left with two choices.

UnityScript, A Version of JavaScript

JavaScript is often seen as a language for beginners; it's easy to learn, the syntax is forgiving and flexible, and it's also used for scripting web pages. JavaScript was initially developed in the mid-1990s by Netscape as a "lite" version of the Java programming language. It was used as a scripting language for web pages, though early on that often meant that various JavaScript functions worked fine in one web browser but didn't work at all in another. The syntax of Java Script was the basis for HTML5 and is very similar to Adobe Flash's ActionScript 3. Despite all of this, it is actually JavaScript's flexibility and forgiving nature that make it an inferior language for this book. As one example, JavaScript uses weak typing, which means that if we were to create a variable (or container) named `bob`, we could put anything we wanted into that variable: a number, a word, an entire novel, or even the main character of our game. Because the variable `bob` doesn't have a variable type, Unity never really knows what kind of thing `bob` is, and that could change at any time. These flexibilities in JavaScript make scripting more tedious and prevent programmers from taking advantage of some of the most powerful and interesting features of modern languages.

C#

C# was developed in 2000 as Microsoft's response to Java. They took a lot of the modern coding features of Java and put them into a syntax that was much more familiar to and comfortable for traditional C++ developers. This means that C# has all the capabilities of a modern language. For you experienced programmers, these features include function virtualization and delegates, dynamic binding, operator overloading, lambda expressions, and the powerful Language INtegrated Query (LINQ) query library among many others. For those of you new to programming, all you really need to know is that working in C# from the beginning will make you a better programmer and prototyper in the long run. In my prototyping class at the

University of Southern California, I taught using both UnityScript and C# in different semesters, and I found that students who were taught C# consistently produced better game prototypes, exhibited stronger coding practices, and felt more confident about their programming abilities than their peers who had been taught UnityScript in prior semesters of the class.

RUNTIME SPEED OF EACH LANGUAGE

If you've had some experience programming, you might assume that C# code in Unity would execute faster than code written in JavaScript or Boo. This assumption would come from the understanding that C# code is usually compiled while JavaScript and Boo are interpreted (meaning that compiled code is turned into a computer's machine language by a compiler as part of the coding process, while interpreted code is translated on-the-fly as the player is playing the game, making interpreted code generally slower). However, in Unity, every time you save a file of C#, UnityScript, or Boo code, Unity imports it, converts any of the three languages to the same Common Intermediate Language (CIL), and then compiles that CIL into machine language. So, regardless of the language you use, your Unity game prototypes will execute at the same speed.

On the Daunting Nature of Learning a Language

There's no way around it, learning a new language is tough. I'm sure that's one of the reasons that you bought this book rather than just trying to tackle things on your own. Just like Spanish, Korean, Mandarin, French, or any other human language, there are going to be things in C# that don't make any sense at first, and there are places that I'm going to tell you to write something that you don't immediately understand. There will also probably be a point where you are just starting to understand some things about the language but feel utterly confused by the language as a whole (which is the exact same feeling you'd have if you took one semester of Spanish class and then tried to watch soap operas on Telemundo). This feeling comes for almost all of my students about halfway through the semester, and by the end of the semester, every one of them feels much more confident and comfortable with both C# and game prototyping.

Rest assured, this book is here for you, and if you read it in its entirety, you will emerge with not only a working understanding of C# but also several simple game prototypes that you can use as foundations on which to build your own projects. The approach that I take in this book comes from many semesters of experience teaching "nonprogrammers" how to find the hidden coder within themselves and, more broadly, how to convert their game ideas into working prototypes. As you'll see throughout this book, that approach is composed of three steps:

1. **Concept introduction:** Before asking you to code anything for each project, I'll tell you what we're doing and why. This general concept of what you're working toward in each tutorial will give you a framework on which to hang the various coding elements that are introduced in the chapter.

2. **Guided tutorial:** You'll be guided step by step through a tutorial that will demonstrate these concepts in the form of a playable game. Unlike some other approaches, we will be compiling and testing the game throughout the process so that you can identify and repair bugs (problems in the code) as you go, rather than trying to fix all of them at the end. Additionally, I'll even guide you to create some bugs so that you can see the errors they cause and become familiar with them; this will make it easier when you encounter your own bugs later.
3. **Lather, rinse, repeat:** In many tutorials, you'll be asked to repeat something. For instance, in a top-down shooter game like *Galaga*, the tutorial would guide you through the process of making one single enemy type, and then it would ask you to create three others on your own. Don't skip this part! This repetition will really drive the concept home, and it will help your understanding solidify later.

pro tip

90% OF BUGS ARE JUST TYPOS I've spent so much time helping students fix bugs that now I can very quickly spot a typo in code. The most common include the following:

- **Misspellings:** If you type even one letter wrong, the computer won't have any idea what you're talking about.
- **Capitalization:** To your C# compiler, `A` and `a` are two completely different letters, so `variable`, `Variable`, and `variAble` are all completely different words.
- **Missing semicolons:** Just like almost every sentence in English should end in a period, nearly every statement in C# should end in a semicolon (;). If you leave the semicolon out, it will often cause an error on the next line. FYI: A semicolon is used because the period was needed for decimal numbers and what's called *dot syntax* in variable names and subnames (e.g., varName.subVarName.subSubVarName).

Earlier, I mentioned that most of my students feel confused and daunted by C# at about the midway point of the semester, and it's at exactly that time that I assign them the Classic Games Project. They are asked to faithfully recreate the mechanics and game feel of a classic game over the course of four weeks. Some great examples have included *Super Mario Bros.*, *Metroid*, *Castlevania*, *Pokemon*, and even the original *Legend of Zelda*. By being forced to work things out on their own, to schedule their own time, and to dig deeply into the inner workings of these seemingly simple games, the students come to realize that they understand much more C# than they thought, and that is the time that everything really falls into place. The key component here is that the thought process changes from "I'm following this tutorial" to "I want to do this...now how do I make it happen?" At the end of this book, you will be prepared to tackle your own game projects (or your own Classic Game Project, if you want). The tutorials in this book can be a fantastic starting point on which to build your own games.

Running Unity for the First Time

Hopefully reading all of that will have given Unity enough time to download in the background. Congratulations! You're about to embark on a challenging but rewarding journey.

Installing Unity

Depending on your personal system settings, the Unity installer should have placed itself in a *Downloads* folder somewhere on your hard drive. I'm sure you've done this kind of thing several times before, so find the file, run the installer with all default options, and let's get to work. This is a big install, so it could take a while. In the final bit of the installation, it may look like it has frozen; but don't worry, just give it some time to complete.

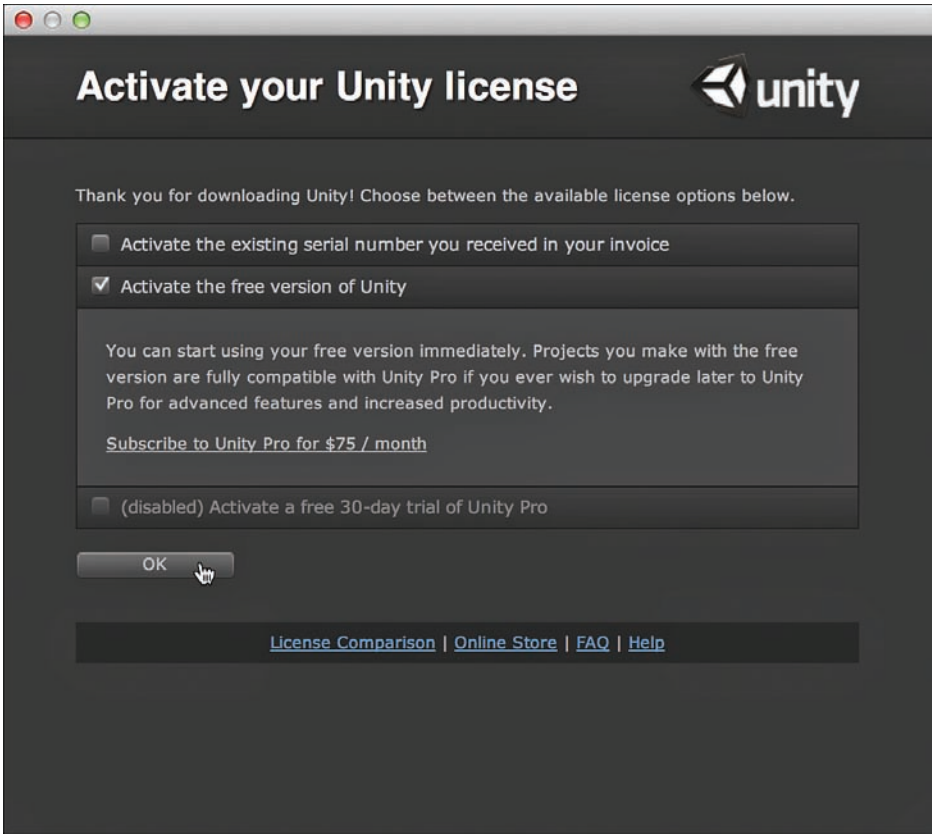
Your First Launch: Licensing

The first time you run Unity, it will open a built-in web page that will ask you to create a license and register (see Figure 16.2), but it's really quite painless, and it shouldn't take much time at all. You will need to choose between the free license and a 30-day trial of Unity Pro. At this time, I recommend activating the free version of Unity, especially if you plan to work through this book slowly. The Pro version will be nice to have for the prototype you'll make in Chapter 34, "QuickSnap," so I recommend waiting until then to start the 30-day trial of Unity Pro. However, choosing the 30-day Unity Pro trial now would allow you to see the beautiful reflections and depth-of-field shaders in Figure 16.4.

You can choose to activate the 30-day trial any time, although you can only activate it once, and once the trial is over, you will be reverted to the free version. If you choose the free version now, you can always go back and upgrade to the Pro trial by selecting *Unity > Manage License* from the menu bar on OS X (on PC, choose *Help > Manage License*).

Once you click *OK*, you are prompted to create a Unity account. They'll send you an email to confirm this (so you need to give them a valid email address). Then, you may be asked to take part in a survey, which you can choose to skip if you want (through a link at the bottom of the survey).

After this, Unity will automatically open the *AngryBots* demo project. This is a large project, so it may take several seconds to load. It may appear that Unity has frozen or is unresponsive, but if you wait a bit, everything will show up.



Activate your Unity license

Thank you for downloading Unity! Choose between the available license options below.

- [ ] Activate the existing serial number you received in your invoice
- [x] Activate the free version of Unity

You can start using your free version immediately. Projects you make with the free version are fully compatible with Unity Pro if you ever wish to upgrade later to Unity Pro for advanced features and increased productivity.

Subscribe to Unity Pro for $75 / month

- [ ] (disabled) Activate a free 30-day trial of Unity Pro

Figure 16.2 Unity licensing window

Example Project: *AngryBots*

When you first launch Unity, it will open a demo project and will show you a *Welcome to Unity* window that pops up over the main Unity window. For now, close the *Welcome to Unity* window, but feel free to explore the introductory videos and other links there later if you want more of an introduction to Unity than is provided in this chapter.

Unless you tell it not to (by holding the Option key at launch), Unity will open an existing project every time you launch it. The default project for this is *AngryBots* (see Figure 16.3), a game created internally by the Unity team to show off the capabilities of the engine. If for some reason the default scene doesn't open automatically, you will need to double-click the *AngryBots* Scene Asset to open it; it should be the first one listed in the Project window pane in the bottom half of the screen. You'll see Project and several other window panes on screen that I'll explain later, but for now, just click the large *Play* button at the top of the Unity window (the triangle pointing to the right in the top, center of the Unity window) and enjoy playing this game for a while. You can read about the controls for this game in the nearby tip.

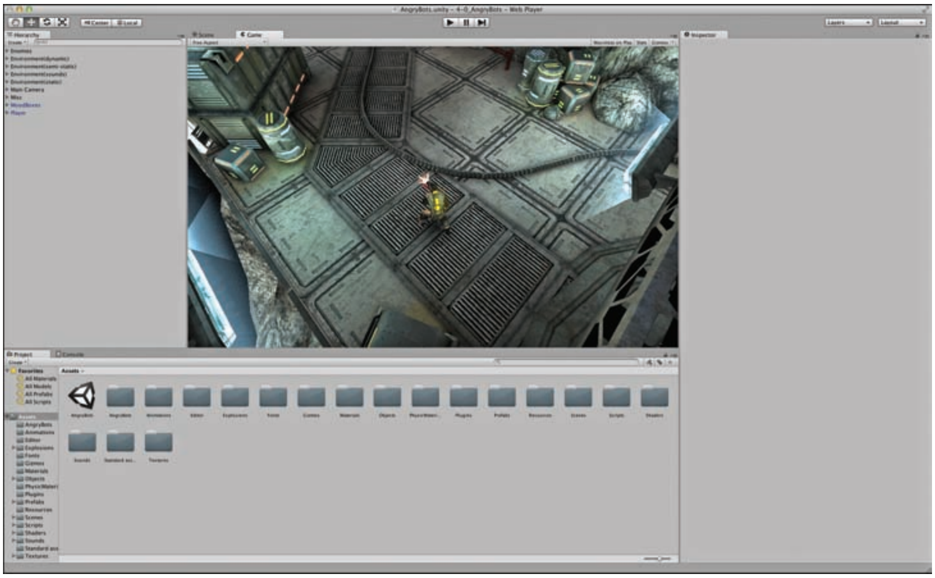


Figure 16.3 The Unity window when it opens for the first time

tip

ANGRYBOTS CONTROLS

- Movement is controlled by the W, A, S, and D or arrow keys.
- The gun will always aim at your mouse pointer.
- Hold down the left mouse button to fire.

You must stand very close to any circular door for a couple of seconds for it to open.

There are several computers that you need to stand in front of in order to unlock them (turn the color of electric wires coming out of them from red to green).

Here are some things to notice while you're playing:

- **Shaders:** AngryBots is rife with *shaders* (see Figure 16.4), code written specifically for the graphics card with the sole purpose of making the game look amazing. Special ones to check out include the following:
  A. The depth-of-field image effect that makes some parts of the scene in-focus while others are out-of-focus (see letter *A* in Figure 16.4). This will only appear in Unity Pro.

B. The reflections on the floors (especially of the laser sight) (see letter *B* in Figure 16.4). This will only appear in Unity Pro.

C. The animated water droplets on the floor when outside (see letter *C* in Figure 16.4). This appears regardless of whether you are using Unity Pro or free.

As explained earlier, if you chose to activate the free license rather than the 30-day Unity Pro trial, you will not see the most advanced shaders. This is one of the few differences between the free and Pro versions of Unity.

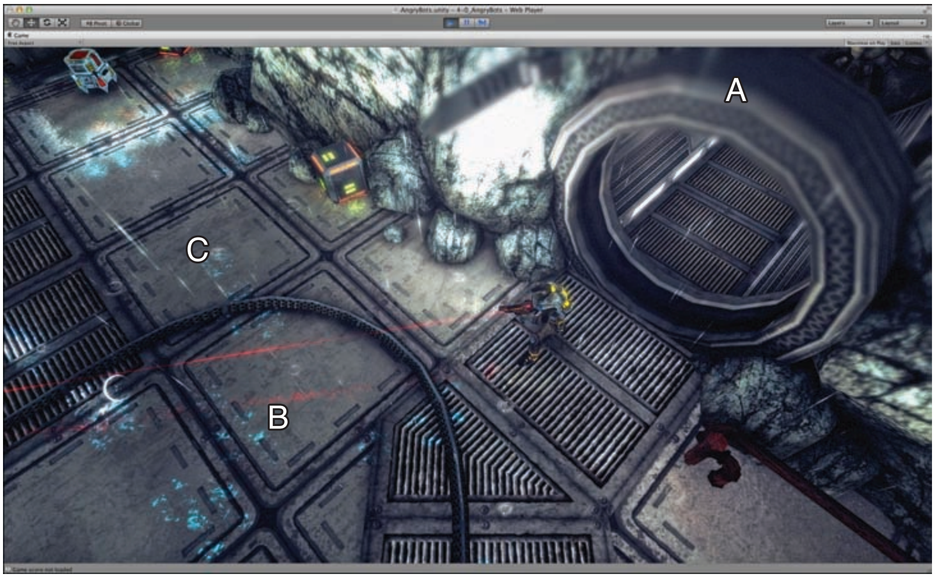


Figure 16.4 Screen showing the effects of various shaders

- **Character rigging and animation:** Unity makes use of animation blending to enable the player character to walk in one direction while looking and shooting in another.
- **AI pathing:** Enemies will move around objects in a room to find and attack the player.

Feel free to explore the whole space and see what elements of AngryBots you might want to use in your own project. Go ahead, I'll wait.

...

...

So, what did you think? Did you blow up the base, or did you escape the exploding station? Did you find the white museum? The controls of this game are a little unusual, but regardless, it's a good showcase for how beautiful Unity can look.

Now, let's do something really cool.

Compile and Deploy AngryBots for the Web

Once you've clicked the blue Stop button at the top of the Unity window (the square next to the Play button), choose *File > Build Settings* from the menu bar (meaning that you should choose the item *Build Settings* from the File menu, as shown in Figure 16.5).

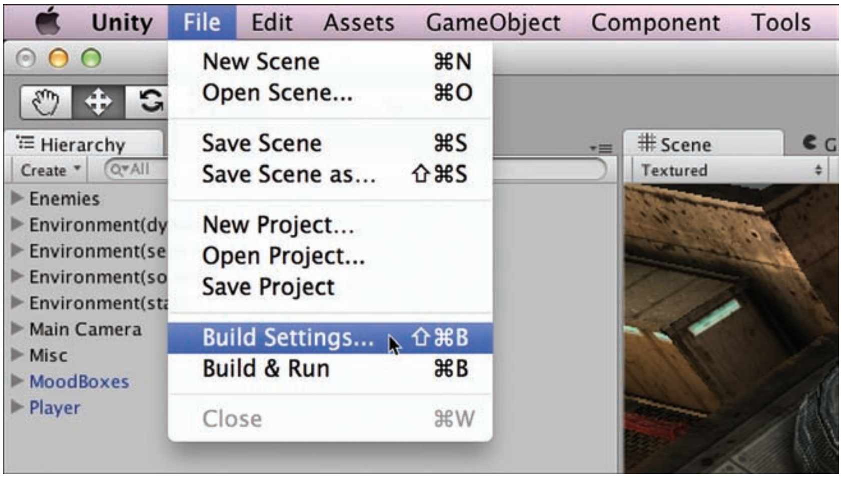
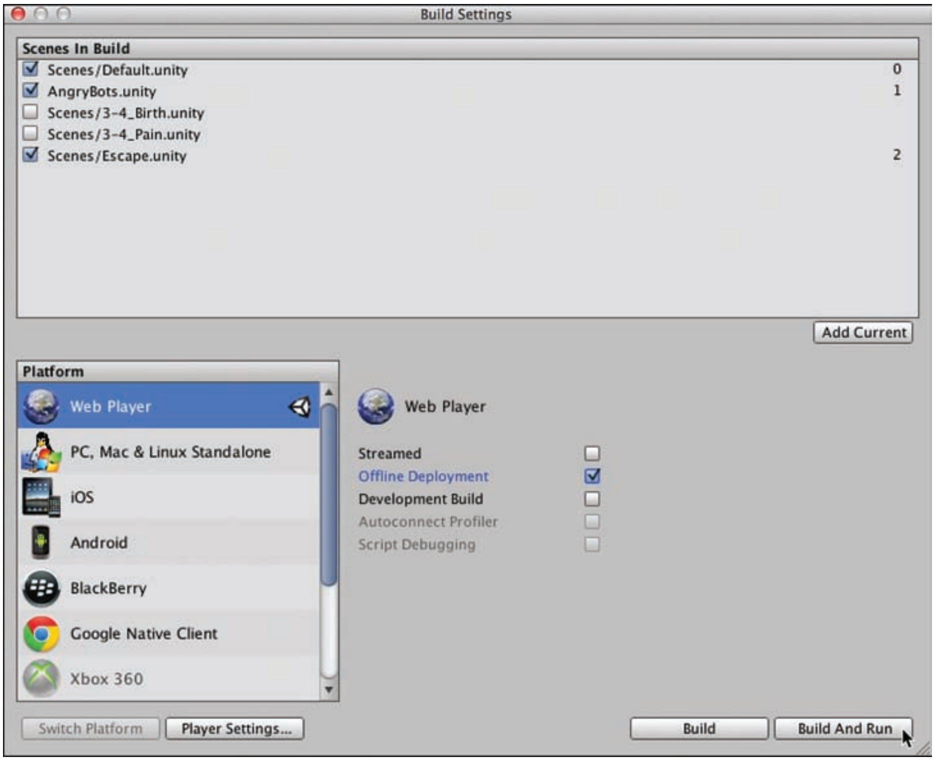


Figure 16.5 Build Settings menu selection

You should see the *Build Settings* window shown in Figure 16.6.

From here, be sure to click *Web Player* on the left and then check *Offline Deployment* in the *Web Player* options area. Click *Build and Run*, and Unity will ask you where to save the files. Type **AngryBots Web Build** for the filename and click *Save*.

Unity will process this for a while and build a web version of the game for you. Once it's built, your web browser will automatically be opened and sent to the page you just made as shown in Figure 16.7. Depending on your browser, you may be prompted to give the Unity plug-in permission to run.



Build Settings

Scenes In Build

✓	Scenes/Default.unity	0
✓	AngryBots.unity	1
☐	Scenes/3-4_Birth.unity	
☐	Scenes/3-4_Pain.unity	
✓	Scenes/Escape.unity	2

Platform: Web Player (selected)

Web Player

Streamed	☐
Offline Deployment	✓
Development Build	☐
Autoconnect Profiler	☐
Script Debugging	☐

Figure 16.6 Unity build settings for the web player

And there you go. You've compiled *AngryBots* for the web. Unity makes things like this very easy so that you can focus on the interesting work: game design and development.

Setting Up the Unity Window Layout

The last thing we need to do before we start actually making things in Unity is to get our environment laid out properly. Unity is very flexible, and one of those flexibilities is that it allows you to arrange its window panes however you like. You can see several window layouts by choosing various options from the *Layout* pop-up menu in the top-right corner of the Unity window (see Figure 16.8).

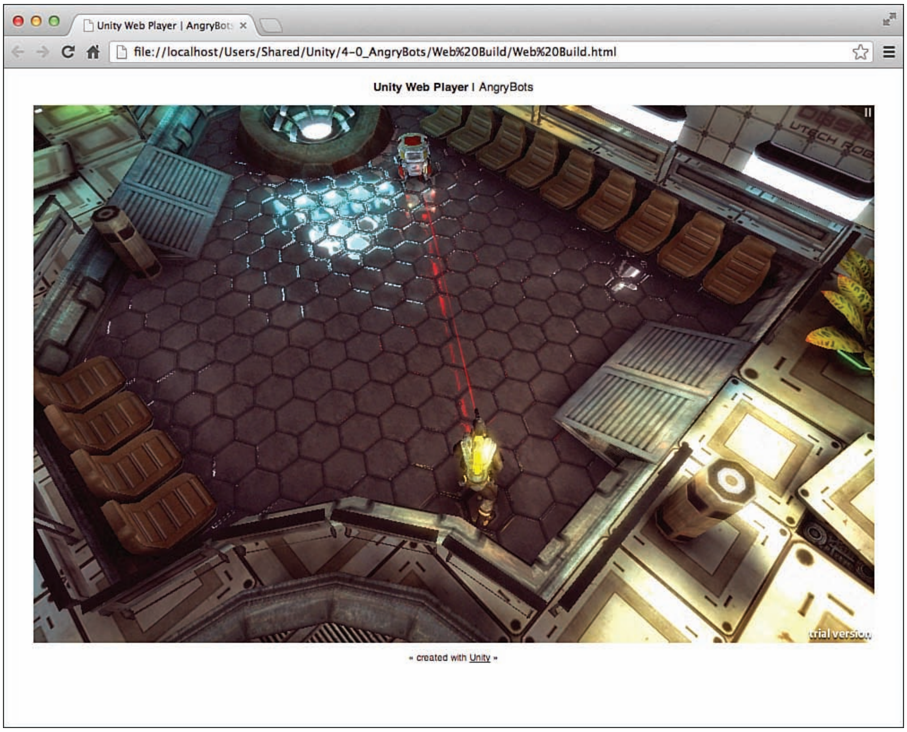

Unity Web Player | AngryBots
file://localhost/Users/Shared/Unity/4-0_AngryBots/Web%20Build/Web%20Build.html
Unity Web Player | AngryBots
trial version
« created with Unity »

Figure 16.7 *AngryBots* running in a browser window

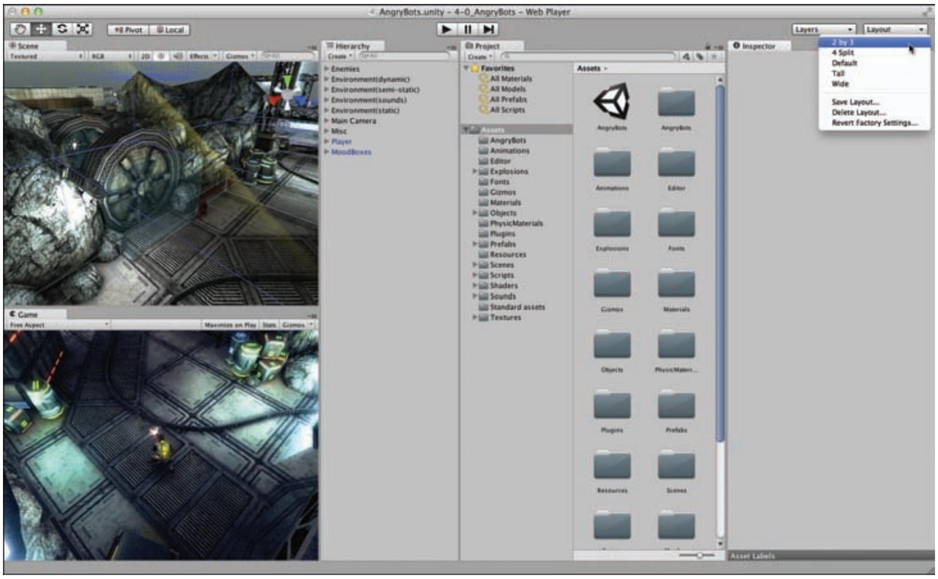


Figure 16.8 Position of the *Layout* pop-up menu and selection of the *2 by 3* layout

Choose *2 by 3* from this pop-up menu. This will be the starting point for making our layout.

Before doing anything else, let's make the Project pane look a little cleaner. Click on the options pop-up for the Project pane (shown in the black circle in Figure 16.9) and choose *One Column Layout*.

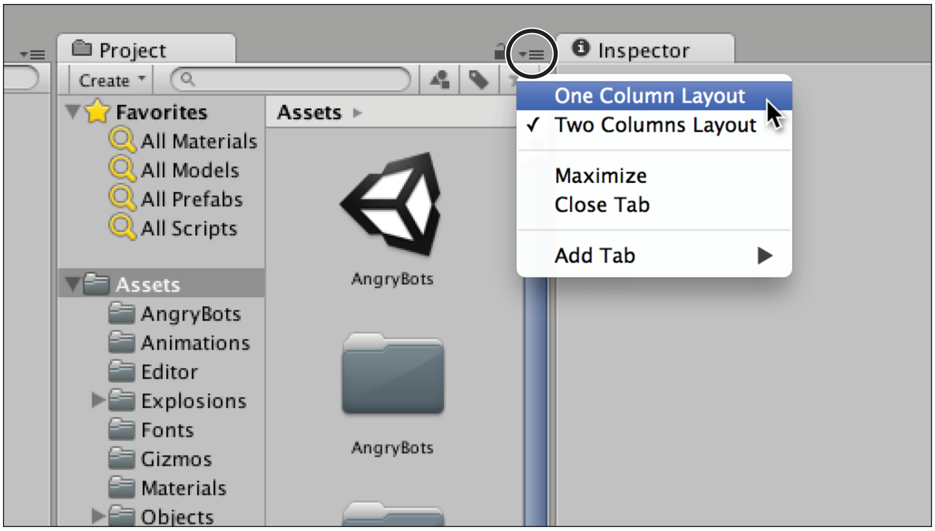


Figure 16.9 Choosing the One Column Layout for the Project pane

Unity enables you to both move window panes around and adjust the borders between them. As shown in Figure 16.10, you can move a pane by dragging its tab (the arrow cursor) or adjust a border between panes by dragging the border between them (the left-right resize cursor).

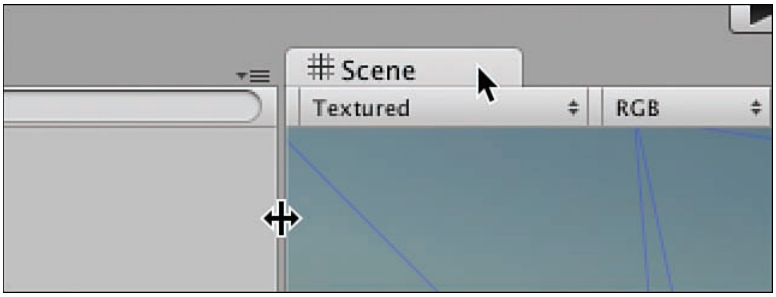


Figure 16.10 Two types of cursors for moving and resizing Unity's window panes

When you drag a pane by its tab, a small ghosted version will appear (see Figure 16.11). Some locations will cause the pane to snap into place. When this happens, the ghosted version of the tab will appear in the new location.

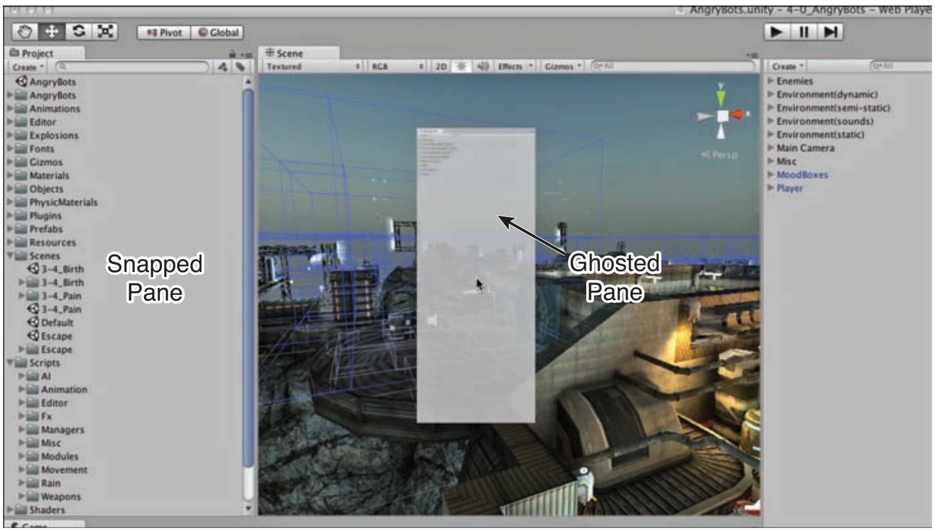


Figure 16.11 Ghosted and snapped panes when moving them around the Unity window

Play around with moving the window panes until your window looks like Figure 16.12.

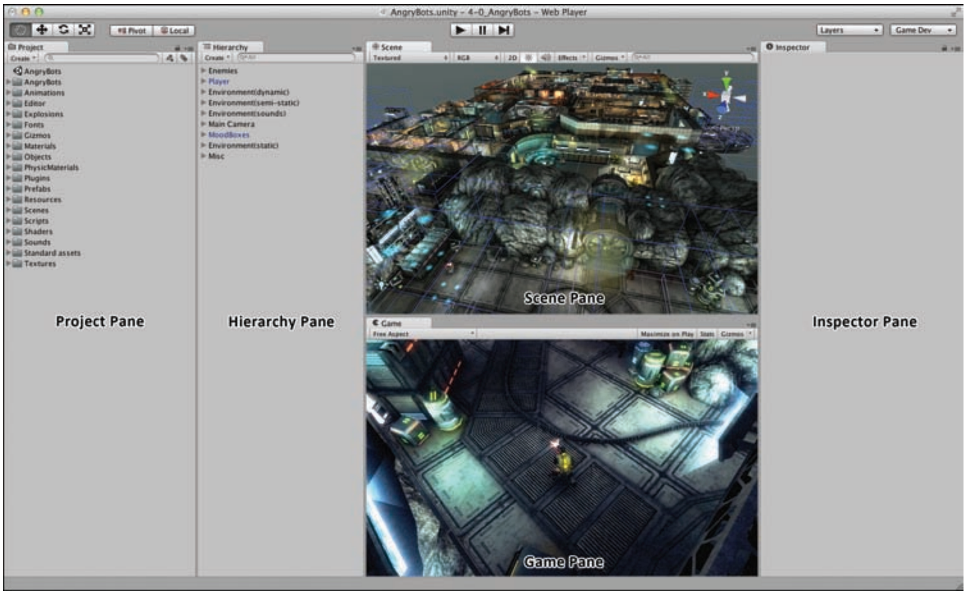


Figure 16.12 Proper layout for the Unity window...but it's still missing something

Now the last thing we need to add is the Console pane. From the menu bar, choose *Window > Console*. Then drag the Console pane below the Hierarchy pane. You'll also need to move the Project pane after you've done this to create the final layout shown in Figure 16.13.

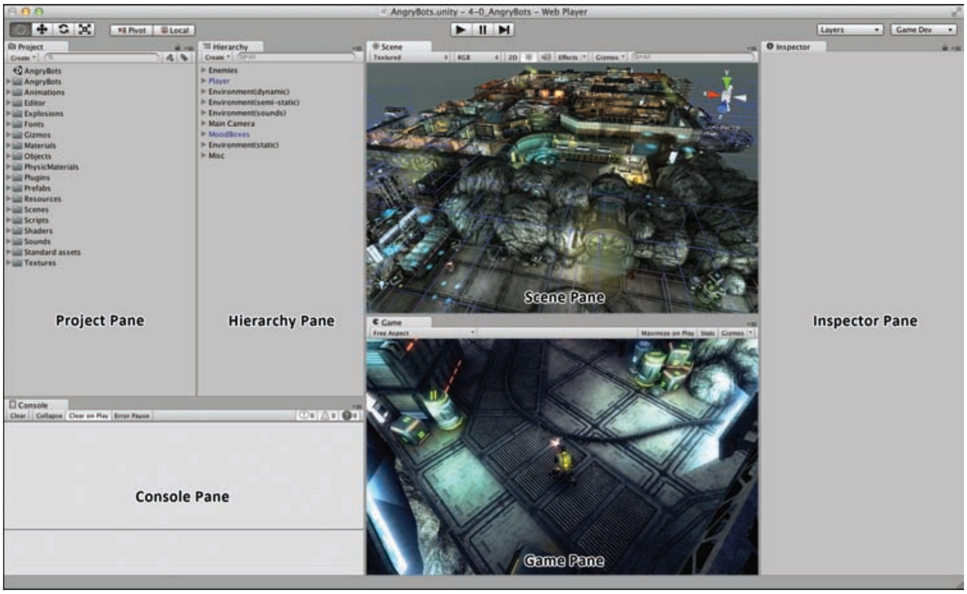


Figure 16.13 Final layout of the Unity window, including the Console pane

Now you just need to save this layout in the Layout pop-up menu so that you don't have to go through all that again. Click the Layout pop-up menu and choose *Save Layout*, as shown in Figure 16.14.

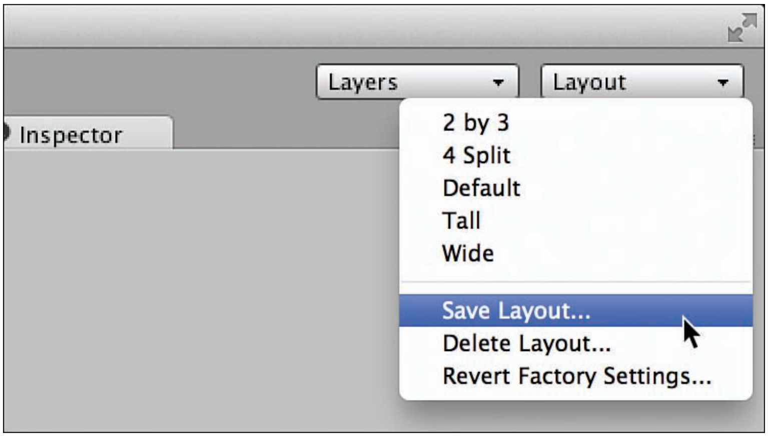


Figure 16.14 Saving the layout

Save this layout with the name *Game Dev*, with a leading space before the G in Game (i.e., " Game Design"). By putting a space at the beginning of the name, you make sure that this layout is sorted to the top of the menu. Now, any time you need to return to this layout, you can simply choose it from this pop-up menu.

Learning Your Way Around Unity

Before we can really get into coding things, you need to get to know the various window panes that you've just arranged. Refer back to Figure 16.13 as we discuss each pane:

- **Scene pane:** The Scene pane allows you to navigate around your scene in 3D and to select, move, rotate, and scale objects.
- **Game pane:** The Game pane is where you will preview your actual gameplay; it's the window in which you played *AngryBots* before compiling the web build. This pane also shows you the view from the *Main Camera* in your scene.
- **Hierarchy pane:** The Hierarchy pane shows you every GameObject that is included in your current scene. For now, you can think of each scene as a level of your game. Everything that exists in your scene, from the camera to your player-character, is a GameObject.
- **Project pane:** The Project pane contains all of the assets that are included in your project. An asset is any kind of file that is part of your project, including images, 3D models, C# code, text files, sounds, fonts and so on. The Project pane is a reflection of the contents of the Assets folder within your Unity project folder on your computer hard drive. These assets are not necessarily in your current scene.
- **Inspector pane:** Any time you click on an asset in the Project pane or a GameObject in the Scene or Hierarchy panes, you will be able to see and edit information about it in the Inspector pane.
- **Console pane:** The Console pane will allow you to see messages from Unity about errors or bugs in your code as well as messages from yourself that will help you understand the inner workings of your own code.[1] We will use the Console pane extensively in Chapter 18, "Hello World: Your First Program," and Chapter 19, "Variables and Components."

Summary

That's it for setup. Now, let's move on to actually developing! As you've seen in this chapter, Unity can create some pretty stunning visuals and compelling gameplay. Though the process of making beautiful 3D models and shaders is outside the scope of this book, it's important for you to know the extent of Unity's graphical capabilities. In the next chapter, you'll learn more about C#, the language you'll be using for game development.

[1] Unity's `print()` and `Debug.Log()` functions allow you to print messages to the Console pane.

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