






# A Human Story of Computer Animation

				
Michael Rubin, Moderator, Author of <i>Droidmaker</i>	Ed Catmull, Co- founder & presi- dent of Pixar Animation Stu- dios	Alvy Ray Smith, Co-founder Pixar Animation Stu- dios, Altamira, Lucasfilm, New York Tech	Andrew Stanton, Writer & Direc- tor, <i>Finding Nemo</i> , Pixar Animation Stu- dios	Brad Bird, Writer & Director, <i>The Incredibles</i> , Pixar Animation Stu- dios

## Abstract

It took 20 years of dreaming, planning and ingenuity to create *Toy Story*, the world's first computer animated full-length feature film, in 1995. It represented a significant departure from the long-established methods of animation, where artists would hand draw characters frame by frame, and painstakingly incorporate movement and color to complete a feature film. Today, thanks to advances in computing power and ingenious software, there is little separation between the refining of an idea and its execution on screen (save for thousands of hours of rendering!).

On May 16, 2005 four self-described geeks — each with a passion to make animated movies — shared how they discovered computer animation, and the obstacles they had to overcome in the process. They presented the entertaining and inspiring tale of how they went from an idea, to a script to the drawing board, to mathematics, to the computer lab ... and ultimately to their Oscar® acceptance speeches.

They described their personal experiences with early computers — developed for code breaking and complex computations — and how they were transformed to develop some of the most memorable images in pop culture today.

## Background

Odysseys in Technology, The Computer History Museum Speaker Series sponsored by Sun Microsystems Laboratories, presents people and perspectives behind extraordinary innovations and advancements in the computer technology-related world. Each event in the Series provides stimulating interaction with authentic experts whose achievements have transformed how things are done or viewed, and examines how their personal stories might inform the present and future. These programs occasionally feature technologies or point events, with the objective to apply lessons of history to present day understanding and inspiration.

## Introduction

The evening started with an introduction by Michael Rubin, a filmmaker, guru, and writer of books, who has worked at Lucasfilm, consulted to Apple and Sony, and even owns a chain of shops where people can paint their own ceramics. Over the last two years, in writing his book, *Droidmaker: George Lucas and the Digital Revolution*, in which Ed Catmull and Alvy Ray Smith are profiled extensively; he studied them, and tried to understand who they are and what drove them.

Michael noted that hanging with Ed Catmull and Alvy Ray Smith was like being able to sit with Paul McCartney and John Lennon of the Beatles. Much of what we take for granted in computer graphics comes from their work over the past decades.

## University of Utah

Alvy Ray Smith started making computer generated pictures when computers still had core memories and lacked displays.

Ed Catmull's thesis was on creating the first computer animated film of his left hand at the University of Utah. He noted that it is important to use vaseline when making a plaster of paris mold of your left hand. It takes a long time for your hair to grow back, if you omit this important step!

The result was that the movie *Futureworld* used Ed's hand. (The neat thing about his movie wasn't that the hand open and closed, but the camera went inside the hand and looked around — something that made people gasp at the time.) In fact, one of the first movies shown in China after the Cultural Revolution was *Futureworld!* (No, no, it was *Porky's!*)

Now his Ph.D. thesis was on showing how you can map an image on to curved patches, what we now know as texture mapping. To do this, he invented the Z-buffer that allowed eliminating computing algorithms.

*Now at this time in the early 1970s, Jim Clark became aware of this, and this ultimately resulted in*

*the founding of Silicon Graphics with its interactive displays.*

People sometimes refer to USC in the late 1960s as the "golden class" for the many filmmakers like George Lucas that came out of the program. Similarly, the University of Utah produced luminaries such as John Warnock, Alan Kay, Ed Catmull and Alvy Ray Smith.

## Go East, Young Man!

Now the next point in our story is when a very wealthy man, Alexander Schure, was interested in putting a 3rd or 4th rate school, New York Institute of Technology on the map.

Now Alvy was working with Dick Shoup at PARC on the Superpaint program. But when Xerox made the decision that they weren't going to do color, he protested, "You're making a big mistake." Sorry, he was told, we've made a corporate decision, so he left PARC.

Alvy visited the University of Utah. Now, up until this point, when you wanted to do color graphics, you used a color wheel and a Polaroid camera, or a film scanner to do one color at a time — you never saw a live picture.

So Alvy walked in, being a young, long haired guy with a beard, saying, "Dude, where's the 8-bit?" Well, Utah was doing some DOD stuff, but they noted that there was this rich guy back in New York who was buying everything in sight and noted that, "he loves animation."

*For a 5 year period, the New York Institute of Technology had more computer graphics equipment than anywhere else on the earth.*

Alvy had proposed to the National Endowment for the Arts for a grant on raster graphic arts, but had been turned down, so he lived the idea of a guy who wanted to make movies. In any event, he ended up going to the New York Institute of Technology, where he started a computer graphics animation effort.

## New York Institute of Technology

They were housed in a four car garage behind a mansion on Long Island, in the same area described in Fitzgerald's *The Great Gatsby*.

Alexander Schure had the desire to create a legacy at the school that would last a long time, thinking that he could use technology to make a big leap beyond Disney. He proceeded to go out and buy one of everything, including in 1974, a \$80,000 8-bit frame buffer, and Evans & Sutherland picture system.

They started on the idea of using the computer to help automate the process of creating "tweens", the intermediate frames of animation between key drawings. At the time this code was being written in PDP-11 assembly language.

Before getting too far along, they talked to Ken Thompson at Bell Labs, who with Dennis Ritchie had created Unix, who convinced them to use it, instead of DEC's RSX-11M operating system.

Now there was a hand drawn animation project going on the same time, called *Tubby the Tuba*. Their first project was to make Tubby dance. But they quickly discovered that the other group was trying to destroy them, with the result that nothing they did went into it, thank goodness!

They were able to get five additional 8-bit frame buffers for \$60K each. By using three of them, they could see things in color. Now keep in mind that in today's dollars, this would be like spending \$1 or \$2 million.

With this hardware, around 1976 they developed the techniques of transparency by inventing the concept of the alpha channel.

## George Lucas

But while they had developed many of the fundamentals of computer graphics, they were not on a path for making film. When George Lucas approached them in 1979, it only took about a nanosecond to decide to leave. Ed

Catmull and Alvy Ray Smith took charge of the new computer research department.

At that time, Lucas had just taken 8 months to finish doing the optical shots for the beginning of *Star Wars*. He decided that it was time to try applying modern technology to the process of making film, synthesizing the audio, and editing. But the real goal was simply to help him make movies.

Eventually the graphics group made an one frame movie, so called because the credits were as long as the movie, that showed a Marin County road overlooking the Pacific Ocean. Fractals were used to create the mountains and plants, the rainbow required fancy texture mapping, and the reflection on the water and pavement required anti-aliasing on the fly.

But the one major fly in the ointment was getting the proper motion blur. In *Star Wars*, by shooting actors against a blue screen, you get the proper blur to emulate live action. If you don't get the proper blur, it causes your eye to see a weird strobing effect.

The combination of Rodney Stock's dithering, Rob Cook's anti-aliasing, and Tom Porter's ability to spread out an image over time, finally met with success in the single frame artwork called *1984* (1984 was spelled out on the pool balls) and was made in 1984.

## The Director's Perspective

Now Brad Bird had first met John Lasseter while they were at Cal Arts. Both John and Brad had worked for Disney and both were let go. They had tried to interest people in doing a computer animated film, but the reaction they got was that no one could hope to make \$50M on an animated film except maybe Disney.

Brad Bird noted that after seeing the movie *Tron*, he was interested in trying to integrate technology into hand drawn animation. While working on *The Fox and the Hound*, he asked why they couldn't use Disney's 4-story multi-plane camera. He was told that it would require \$150K to \$200K for the shot, due to the large number of union members that would be

required to move each cell, frame by frame. But Brad observed that using servos, you could make the cost reasonable.

Similarly, it seemed like you could use the computer to hand color cels, to automate the process of doing old style animation.

People forget that animation is about art, as opposed to creating real looking images. While trying to create a real looking image is a benchmark, it is undesirable to make a film that looks this way. In *Finding Nemo*, we worked for 2 months in being able to recreate shots of a whale and reef, and it looked unbelievably good. But if we had done that, no one would have believed that fish could talk!

Go and look at *Bambi*. If you look closely, there are only vague impressions in the background, yet it is evocative of what it feels like to be in a forest.

For *Finding Nemo*, everyone involved got to go scuba diving in Hawaii at company expense. (For *The Incredibles*, Brad put on a cape and ran around his living room.) But by scuba diving, the animators were able to feel what it felt like to be under water.

When people talk about purple mountains, they don't realize that there are all these discrete colors that they are actually seeing, that they don't consciously recognize.

## Telling Great Stories

Now Andrew and Brad, while knowing squat about technology, and still being able to make great movies, also respect the great technologies at Pixar. The directors come up with the idea for a shot, than the technology people say, "but you can't do that," and than they go ahead and figure out how to do it. Movie making drove the advancements of Pixar's technology.

But in watching a movie, you don't think about the technical feats of animating hair, you get sucked into the movie. But when you talk to the press, they want to know what's new? Blue fur? Nose hair? Wow! So many people focus on the wrong thing. The goal is to tell a great

story, to provide a great and wonderful adventure.

Our crowning glory was that in *Toy Story*, in reviews there was only one line about it being a computer animated film, the rest of the reviews were all about the story.

When we were making our first feature film, people questioned whether anyone would sit through a 70 minute film. But they forgot that the same question was asked in 1937 for the first Disney animated film. What is really hard is to sit through the 2 hour movie of *Alexander*!

Pixar's first short animated film was *Luxo Jr.* in 1986. First shown at Siggraph, it shows a big lamp interacting with a small lamp and a ball. They knew they had a success, when everyone asked if the big lamp was a father or mother!

This is why Pixar is successful, we are passionate about telling stories. We put all of our efforts into telling the best story possible. There are a lot of Pixar want-to-be companies that are producing horrible films.

Brad Bird is fairly new to computer animation, but notes that it is much the same as hand animation. Nobody talks about how many frames are in a movie or notes in a symphony. Rather the emotion and art of the work is what matters. Look at films like *Star Wars*, *Wizard of Oz*, and *Snow White*. Even after decades have passed, the stories still are compelling and hold up.

## Why Imitators Fail

After the success of *Lion King*, there was a string of imitators that all failed. People have the belief that you can take a lousy idea, put it through a computer, and make it into something good. Ah, new and better ways to make all my ideas into gold!

The media wants a simple story as to why we make great movies. Pixar is a group that does something incredibly well together. We are continually morphing to try to maximize our potential.

In the 1930s, Walt Disney developed innovative technology to make his animated films. Today Pixar uses computer animation to do the same thing. Today's technology simply allows new visions of art to be told — you still have to care about the characters. Even though *Toy Story* is 10 years old, you still get drawn in.

In a way, we were so frustrated with the morbid state of animation in the 1980s. It was like a fairy tale, add songs, one of which had to be a “what I want” song, with a side kick character. We were driven that there had to be a better story that could be told.

## A Turning Point

*Toy Story 2* was a crisis point for Pixar. It started out as a direct to video, grade B movie. But we stopped in the middle of it, and realized that it was violating our mantra, that we don't do anything unless we can make it great.

This is not to say that we can guarantee our success, but rather that we will only do something where we try our best.

So the challenge that you have after making a string of five hits is that you get complacent, your enemy becomes yourself. You get tired from continually working so hard.

Brad Bird chimed in, “So they bring me in, knowing, we'll get the guy who did the big bomb (*Iron Giant*), and we can blame him for taking the company down the tubes!”

## Question and Answer

***What is your perspective on the fight between Hollywood and Silicon Valley on content?***

Brad Bird noted that the objective is to give people the freedom to do what they want, without ripping off the artist. Steve Jobs with iTunes is a great model for how this can be done.

But there are fond memories of standing in line to see a movie, it was part of the whole experience of seeing a show. The many different ways that you can see a movie today, dimin-

ishes the experience. All in all, I'm glad that Steve's on our side!

***Many of you had the long hair and beard hippy experience, how did that effect you in doing computer animation?***

To laughter in the audience, Brad Bird chimed in, “He doesn't remember.” It was noted that John Markoff's new book, *What the Dormouse Said: How the 60's Counterculture Shaped the Personal Computer*, talks about this at length.

***What has been the impact of technology on computer animation?***

We had a Cray supercomputer salesman who was anxious to have Pixar use it when we were getting started. We were making our short film, *Andre & Wally B*, and tried doing our motion blur with it. We brought the Cray to its knees trying to render just the first frame!

At SIGGRAPH the last third of *Andre & Wally B* was all line drawings. But most of the audience didn't notice, they were too drawn into the story.

***What Easter Eggs are present in Pixar films?***

All of the animation classes at California Institute of the Arts were held in A113. The *Family Dog* short started using this, and you'll find it in all Pixar films since. Similarly, if you look at the titles of the books on a shelf, or the Eggman Movers on the side of a truck, they all are inside references.

***How will live action and computer animation become integrated?***

In movies like *Lord of the Rings*, it already is. When you see a stunt like Tom Cruise jumping off a train and not dying, with photo realism, stuntmen, blue screen, and texture mapping are all being used so you see Tom's face on the stuntman.

Increasingly, every frame in a film is being manipulated digitally. But just because you can be real, doesn't mean that you should. In *The Incredibles*, we deliberately chose the hands to be twice normal size, yet kept the proper weight

and inertia of the characters, because this was crucial to maintaining believability. The same considerations went into making *Finding Nemo*, you have to make it believable.

### ***What films, writers, and directors have influenced you in the making of your films?***

For writers, David Lemon, Robert Bolt, David Mamoth (his economy of writing) come to mind. For directors, Hitchcock, Disney, Chaplin, and Benigni are favorites. Robert Towne, Billy Wilder, Francis Ford Coppola, and Preston Sturges are others.

### ***How has the pacing of films changed?***

Sometimes you feel like directors have attention deficit disorder. They get nervous and frantic, worried that the audience has a remote and will change the channel, so they do a cut every 2 seconds.

I hate that, you need to have the proper pacing and take the necessary time to let anticipation build.

In the short, *Family Dog*, you see the dog food being poured out of a can. As it slowly oozes out of the can, the dog goes from wild anticipation to losing interest.

Steven Spielberg is a master of this technique. Everyone focuses on the *Jurassic Park* dinosaurs chasing the car, they forget the cup of water shaking with each step of the T Rex as it approaches.

### ***What is the process of making an animated film?***

Thank God that they take four years to make and that they let us try and try again. "When are you going to get it right," they ask. All I know is that I'm going to get it wrong, really soon.

At Pixar, they don't let you get away with anything. They let you know what is wrong, in a very constructive manner.

There is a story of a director at a rehearsal, dancers waiting on stage for direction, who is slumped over with head on his arms. The producer walks in, and asks what's going on. The

director replies, "I don't know what to do." The producer retorts, "Well do something so we can change it."

### ***What makes a good animated film?***

An animated film is only as good as your animators. The problem is that it is easy to become stale. You can learn animation by single framing through other people's work, but ultimately it is like eating your own tail.

To be original, like the early Disney films, you look elsewhere. That is why we encourage animators to take sculpture, drama, and theater classes. We rarely talk about other animated films, we look for our inspiration in mainstream cinema.

### ***What will happen to traditional hand drawn animation?***

Ed Catmull recently went to Cal Arts, where he noted that a lot of schools are killing their hand drawing classes. But being able to use pencil and paper is a tremendous asset in helping you to communicate.

People get caught up in computer animation, thinking that 3D has made 2D obsolete. They are wrong. The failure of 2D films comes from having forgotten how to tell stories. What software does is to enhance your animation skills, so you can be more productive.

### ***Where can I find out more about the history of Pixar?***

Well, in October 2005, you'll be able to get Michael Rubin's book, *Droidmaker: George Lucas and the Digital Revolution*. And with the 20th anniversary of Pixar in 2006, there will undoubtedly be a book than.

### ***Would Iron Giant have been more successful if it were done in 3D?***

The major cause of the failure of *Iron Giant* was due to Warner Brothers' marketing. At the time *Iron Giant* was being made, they were closing down the animation division. We felt like we were on the Titanic in the last 2 hours before it sunk. We joked that they had forgotten to turn off the power, so we made a film!

But when the film tested with audiences, it got the highest scores of any Warner Brothers film in 50 years.

Originally, *The Incredibles* was going to be a 2D film. But there is such an amazing group at Pixar, having the ability to get facial expressions on character's faces.

Unfortunately, the world is so enamored with 3D today, that about the only place where 2D can still thrive is Japan.

## About the Author

Mark Duncan is a marketing consultant who focuses on emerging technologies, assisting companies in entering new markets and developing new business opportunities. He can be contacted at [mark@askmar.com](mailto:mark@askmar.com). This article and others can be found at [www.askmar.com](http://www.askmar.com)

# Speaker

## Backgrounds

### Michael Rubin, Moderator, Author of *Droidmaker: George Lucas and the Digital Revolution*

Michael Rubin is an educator, author and filmmaker dedicated to empowering people with new media tools. After graduating from Brown University with a degree in neuroscience, he began his career at Lucasfilm's Droid Works. From 1985-1994 he designed editing equipment and edited feature films and television shows in Hollywood. Since then, Rubin has lectured internationally, from Montreux to Beijing, and has published a number of texts on editing for professionals as well as consumers, including *Nonlinear*, *The Little Digital Video Book*, and Apple's *iLife '05*. He has consulted for businesses such as Sony and Apple regarding video literacy; he is also the co-founder and CEO of Petroglyph Ceramic Lounge, a creative retail chain in the Bay Area. His latest book, *Droidmaker: George Lucas and the Digital Revolution* (Triad; October 2005) explores the evolution of entertainment technologies at the Lucasfilm Computer Division.

### Ed Catmull, Co-Founder and President, Pixar Animation Studios

Dr. Catmull is president and co-founder of Pixar Animation Studios. Previously he was vice president of the Computer Division of Lucasfilm, Ltd., where he managed four development efforts in the areas of computer graphics, video editing, video games and digital audio. Dr. Catmull has been honored with three Scientific and Technical Engineering Awards from The Academy of Motion Picture Arts and Sciences for his work, including an Oscar®. He also won the Coons Award, which is the highest achievement in the computer graphics field, for his lifetime contributions and was awarded the animation industry's Ub

Iwerks Award. Dr. Catmull is a member of the Academy of Motion Picture Arts and Sciences and the National Academy of Engineering. Dr. Catmull earned his B.S. degrees in computer science and physics and his Ph.D. in computer science from the University of Utah.

### Alvy Ray Smith, Co-Founder of four centers of computer graphics excellence (Altamira, Pixar, Lucasfilm, New York Tech) and a Microsoft Fellow

Dr. Alvy Ray Smith co-founded four centers of computer graphics excellence before joining Microsoft as its first Graphics Fellow: Altamira, Pixar, Lucasfilm, New York Tech. He received two technical Academy Awards for alpha channel concept and for digital paint systems. He also invented, directed, originated, or otherwise instrumental in the following developments: early full-color paint program, HSV color model, alpha channel and image sprites, Genesis Demo in *Star Trek II: The Wrath of Khan*, first Academy-Award winning computer-generated short *Tin Toy*, first computer-generated film *Toy Story*, Academy-Award winning Disney animation production system CAPS, and the Visible Human Project. He was a star witness in a trial that successfully invalidated five patents that had been plaguing the digital imaging business. Dr. Smith writes and speaks extensively and has served on the Microsoft Art Committee. He has a PhD from Stanford University and honorary doctorate from New Mexico State University. Retired in 1999, Dr. Smith devotes time to the emerging artform of digital photography and to scholarly genealogy, to which he has contributed a prize-winning book and several journal papers. See website <http://alvyray.com>.

### Andrew Stanton, Writer/ Director, *Finding Nemo*, Pixar Animation Studios

Andrew Stanton has been a major creative force at Pixar Animation Studios since 1990, when he became the second animator, and



ninth employee, to join the company's elite group of computer animation pioneers. Stanton made his directorial debut on the record-shattering *Finding Nemo* after serving as co-writer, co-director, executive producer, and story artist on all four previous acclaimed Pixar films, which were presented by Walt Disney Pictures. *Finding Nemo* was awarded an Oscar® for Best Animated Feature Film of 2003, the first such honor Pixar Animation Studios has received for a full-length feature.

Stanton was one of the four screenwriters to receive an Oscar® nomination in 1996 for his contribution to *Toy Story* and went on to receive credit as a screenwriter on every subsequent Pixar film - *A Bug's Life*, *Toy Story 2*, *Monsters, Inc.* and *Finding Nemo*. Additionally, he served as co-director on the 1998 Walt Disney Pictures presentation of a Pixar Animation Studios film, *A Bug's Life*, and was the executive producer of the 2001 Oscar®-nominated hit *Monsters, Inc.*

A native of Rockport, Massachusetts, Stanton earned a BFA in character animation from California Institute of the Arts (Cal Arts), where he completed two student films: *A Story* (a tale of a boy named Melvin, a dinosaur named Ted, and a killer clown with a goon squad named Randy) and *Somewhere in the Arctic*. In the 1980s, he launched his professional career in Los Angeles animating for Bill Kroyer's Kroyer Films studio, and writing for Ralph Bakshi's production of *Mighty Mouse, The New Adventures* (1987). In 1990, he joined John Lasseter at his fledgling commercial production company, Pixar, and served as directing animator and director on numerous commercials.

Stanton and John Lasseter co-directed the Luxo, Jr. shorts *Surprise* and *Light and Heavy* for Sesame Street before beginning preproduction on *Toy Story* in the early 1990s.

## Brad Bird, Writer/Director, *The Incredibles*, Pixar Animation Studios

Brad Bird is the director of the Academy Award®-winning, film *The Incredibles*, the latest computer animated comedy-adventure from Pixar Animation Studios. *The Incredibles*, based upon an original screenplay written by Bird, is about a family of super heroes forced to go under cover and adopt civilian identities.

Prior to joining Pixar, Bird wrote and directed the critically acclaimed 1999 animated feature, *The Iron Giant*, which won the International Animated Film Society's Annie Award for Outstanding Achievement in an Animated Theatrical Feature.

Bird began his first animated film at the age of 11, and finished it nearly three years later. The film brought him to the attention of The Walt Disney Studios where, at age 14, he was mentored by Milt Kahl, one of a distinguished group of Disney's legendary animators known as the "Nine Old Men." Bird eventually worked as an animator at Disney and other studios.

Bird's credits include acting as executive consultant on *The Simpsons*, the longest running and most celebrated animated television series of all time, and *King of the Hill*. He also created, wrote, directed and co-produced the Family Dog episode of Steven Spielberg's *Amazing Stories*, and co-wrote the screenplay for the live-action feature \*batteries not included.