



DVD Frequently Asked Questions (and Answers)

This is the November 11, 2004 revision of the official Internet DVD FAQ for the rec.video.dvd Usenet newsgroups.

([See below](#) for what's new.) Send corrections, additions, and new questions to Jim Taylor <jtfrog@usa.net>.

This FAQ is updated at least once a month. If you are looking at a version more than a month old, it's an out-of-date copy. The most current version is at [DVD Demystified](#).

Contents

- [\[0\] Where can I get the DVD FAQ?](#)
 - [\[0.1\] Has the DVD FAQ been translated into other languages?](#)
 - [\[0.2\] This FAQ is too long and technical. Is there a simpler version?](#)
 - [\[0.3\] Is this FAQ any good? Who wrote it? How do I know it's accurate?](#)
 - [\[0.4\] How big is this thing?](#)
- [\[1\] General DVD](#)
 - [\[1.1\] What is DVD?](#)
 - [\[1.2\] What are the features of DVD-Video?](#)
 - [\[1.3\] What's the quality of DVD-Video?](#)
 - [\[1.4\] What are the disadvantages of DVD?](#)
 - [\[1.5\] What DVD players and drives are available?](#)
 - [\[1.5.1\] Which player should I buy?](#)
 - [\[1.6\] What DVD titles are available?](#)
 - [\[1.6.1\] Where can I read reviews of DVDs?](#)
 - [\[1.6.2\] How do I find out when a movie or TV show will be available on DVD?](#)
 - [\[1.6.3\] Why isn't my favorite movie on DVD?](#)
 - [\[1.6.4\] How can I find DVDs with specific features or characteristics?](#)
 - [\[1.6.5\] Why do some rental stores and retailers not carry widescreen DVDs?](#)
 - [\[1.7\] How much do players and drives cost?](#)
 - [\[1.8\] How much do discs cost?](#)
 - [\[1.9\] How is DVD doing? Where can I get statistics?](#)
 - [\[1.10\] What are "regional codes," "country codes," or "zone locks"?](#)
 - [\[1.11\] What are the copy protection issues?](#)
 - [\[1.12\] What about DVD-Audio or Music DVD?](#)

- [\[1.12.1\] What's the difference between DVD-Audio discs and DVD-Music discs?](#)
- [\[1.13\] Which studios support DVD?](#)
- [\[1.14\] Can DVD record from TV/VCR/etc?](#)
- [\[1.15\] What happens if I scratch the disc? Aren't discs too fragile to be rented?](#)
- [\[1.16\] VHS is good enough, why should I care about DVD?](#)
- [\[1.17\] Is the packaging different from CD?](#)
- [\[1.18\] What's a dual-layer disc? Will it work in all players?](#)
- [\[1.19\] Is DVD-Video a worldwide standard? Does it work with NTSC, PAL, and SECAM?](#)
- [\[1.20\] What about animation on DVD? Doesn't it compress poorly?](#)
- [\[1.21\] Why do some discs require side flipping? Can't DVDs hold four hours per side?](#)
- [\[1.22\] Why is the picture squished, making things look too skinny?](#)
- [\[1.23\] Do all videos use Dolby Digital \(AC-3\)? Do they all have 5.1 channels?](#)
- [\[1.24\] Can DVDs have "laser rot"?](#)
- [\[1.25\] Which titles are pan & scan only? Why?](#)
- [\[1.26\] How do I make the subtitles on my Pioneer player go away?](#)
- [\[1.27\] Why does playback sometimes freeze for a second?](#)
- [\[1.28\] The disc says Dolby Digital. Why do I get 2-channel surround audio?](#)
- [\[1.29\] Why doesn't the repeat A-B feature work on some discs?](#)
- [\[1.30\] What's the difference between first, second, and third generation DVD?](#)
- [\[1.31\] What's a hybrid DVD?](#)
- [\[1.32\] What's the deal with DTS and DVD?](#)
- [\[1.33\] Why is the picture black and white?](#)
- [\[1.34\] Why are both sides fullscreen when one side is supposed to be widescreen?](#)
- [\[1.35\] Why are the audio and video out of sync?](#)
- [\[1.36\] Why does the picture alternate between light and dark?](#)
- [\[1.37\] How do I find "Easter eggs" and other hidden features?](#)
- [\[1.38\] How do I get rid of the black bars at the top and bottom?](#)
- [\[1.39\] How should I clean and care for DVDs?](#)
- [\[1.40\] What's a progressive DVD player?](#)
- [\[1.41\] Why doesn't disc X work in player Y?](#)
- [\[1.42\] How do the parental control and multi-ratings features work?](#)
- [\[1.43\] Which discs include multiple camera angles?](#)
- [\[1.44\] Is it ok to put labels or magnetic strips on DVDs?](#)
- [\[1.45\] What's the difference between Closed Captions and subtitles?](#)
- [\[1.46\] What do the "D" codes on region 2 DVDs mean?](#)

- [\[1.47\] What's firmware and why would I need to upgrade it?](#)
- [\[1.48\] Are there discs to help me test, optimize, or show off my audio/video system?](#)
- [\[1.49\] What do Sensormatic and Checkpoint mean?](#)
- [\[1.50\] What are Superbit, Infinifilm, and other variations of DVD?](#)
- [\[1.51\] I don't know the parental control password for my player. What do I do?](#)
- [\[1.52\] Can my DVD player get a virus?](#)
- [\[2\] DVD's relationship to other products and technologies](#)
 - [\[2.1\] Will DVD replace VCRs?](#)
 - [\[2.2\] Will DVD replace CD?](#)
 - [\[2.3\] Can CD-R writers create DVDs?](#)
 - [\[2.4\] Is CD compatible with DVD?](#)
 - [\[2.4.1\] Is CD audio \(CD-DA\) compatible with DVD?](#)
 - [\[2.4.2\] Is CD-ROM compatible with DVD-ROM?](#)
 - [\[2.4.3\] Is CD-R compatible with DVD?](#)
 - [\[2.4.4\] Is CD-RW compatible with DVD?](#)
 - [\[2.4.5\] Is Video CD compatible with DVD?](#)
 - [\[2.4.6\] Is Super Video CD compatible with DVD?](#)
 - [\[2.4.7\] Is Picture CD or Photo CD compatible with DVD?](#)
 - [\[2.4.8\] Is CD-i compatible with DVD?](#)
 - [\[2.4.9\] Is Enhanced CD compatible with DVD?](#)
 - [\[2.4.10\] Is CD+G compatible with DVD?](#)
 - [\[2.4.11\] Is CDV compatible with DVD?](#)
 - [\[2.4.12\] Is MP3 compatible with DVD?](#)
 - [\[2.4.13\] Is HDCD compatible with DVD?](#)
 - [\[2.5\] Is laserdisc compatible with DVD?](#)
 - [\[2.6\] Will DVD replace laserdisc?](#)
 - [\[2.7\] How does DVD compare to laserdisc?](#)
 - [\[2.8\] Can I modify or upgrade my laserdisc player to play DVD?](#)
 - [\[2.9\] Does DVD support HDTV \(DTV\)? Will HDTV make DVD obsolete?](#)
 - [\[2.10\] What is Divx?](#)
 - [\[2.11\] How can I record from DVD to videotape?](#)
 - [\[2.12\] Will high-definition DVD or 720p DVD make current players and discs obsolete?](#)
 - [\[2.13\] What effect will FMD have on DVD?](#)
 - [\[2.14\] How does MPEG-4 affect DVD?](#)
 - [\[2.15\] What's WebDVD?](#)

- [\[2.16\] What's a Nuon player?](#)
- [\[2.17\] What effect will D-VHS have on DVD?](#)
- [\[3\] DVD technical details](#)
 - [\[3.1\] What are the outputs of a DVD player?](#)
 - [\[3.2\] How do I hook up a DVD player?](#)
 - [\[3.2.1\] Will I have problems connecting my VCR between my TV and my DVD player?](#)
 - [\[3.2.2\] Why is the audio or video bad?](#)
 - [\[3.3\] What are the sizes and capacities of DVD?](#)
 - [\[3.3.1\] When did double-sided, dual-layer discs \(DVD-18\) become available?](#)
 - [\[3.4\] What are the video details?](#)
 - [\[3.4.1\] What does "lines of resolution" mean?](#)
 - [\[3.5\] What's widescreen? How do the aspect ratios work?](#)
 - [\[3.6\] What are the audio details?](#)
 - [\[3.6.1\] Details of DVD-Audio and SACD](#)
 - [\[3.6.2\] Audio details of DVD-Video](#)
 - [\[3.6.3\] Can you explain this Dolby Digital, Dolby Surround, Dolby Pro Logic, DTS stuff in plain English?](#)
 - [\[3.6.4\] Why is the audio level from my DVD player so low?](#)
 - [\[3.6.5\] Why is the dialog hard to hear?](#)
 - [\[3.7\] How do the interactive features work?](#)
 - [\[3.8\] What is the difference between interlaced and progressive video?](#)
 - [\[3.9\] What is edge enhancement?](#)
 - [\[3.10\] Does DVD work with barcodes?](#)
 - [\[3.11\] What is BCA or NBCA?](#)
 - [\[3.12\] How long do DVDs last?](#)
 - [\[3.13\] What about the HD-DVD and blue laser formats?](#)
- [\[4\] DVD and computers](#)
 - [\[4.1\] Can I play DVD movies on my computer?](#)
 - [\[4.1.1\] Can I play DVD-Audio discs on my computer?](#)
 - [\[4.2\] What are the features and speeds of DVD drives?](#)
 - [\[4.2.1\] What is the audio output connector on a DVD drive for?](#)
 - [\[4.3\] What about recordable DVD: DVD-R, DVD-RAM, DVD-RW, DVD+RW, and DVD+R?](#)
 - [\[4.3.1\] Is it true there are compatibility problems with recordable DVD formats?](#)
 - [\[4.3.2\] DVD-R](#)
 - [\[4.3.3\] DVD-RW](#)

- [\[4.3.4\] DVD-RAM](#)
 - [\[4.3.4.1\] How do I remove a DVD-RAM type 2 disc from the cartridge?](#)
- [\[4.3.5\] DVD+RW and DVD+R](#)
- [\[4.3.6\] Which recordable DVD format should I buy?](#)
- [\[4.3.7\] Other recordable optical formats](#)
- [\[4.3.8\] How long does DVD recording take?](#)
- [\[4.3.9\] Which color of recordable DVD is best?](#)
- [\[4.3.10\] When will dual-layer recordable DVDs be available?](#)
- [\[4.3.11\] What does 2x, 4x, 16x, and so on mean on recordable discs, and which one should I use?](#)
- [\[4.4\] Why can't I take a screenshot of DVD video? Why do I get a pink or black square?](#)
- [\[4.5\] Why can't I play movies copied to my hard drive?](#)
- [\[4.6\] Why do I have problems playing DVDs on my computer?](#)
- [\[4.7\] Can I stream DVD over a network or the Internet?](#)
- [\[4.8\] What is DeCSS?](#)
- [\[4.9\] How do I play DVD video in HTML, PowerPoint, Director, VB, etc.?](#)
- [\[4.10\] What are .IFO, .VOB, and .AOB files? How can I play them?](#)
- [\[4.11\] How do I get the Microsoft Windows DVD player application to run?](#)
- [\[4.12\] I upgraded to Windows XP, why did my DVD software stop working?](#)
- [\[4.13\] How can I rip audio from a DVD to play as MP3 or burn to a CD?](#)
- [\[5\] DVD production](#)
 - [\[5.1\] How much does it cost to produce a DVD? Isn't it more expensive than videotape, laserdisc, and CD-ROM?](#)
 - [\[5.2\] What DVD-ROM formatting tools are available?](#)
 - [\[5.3\] What DVD production tools are available?](#)
 - [\[5.3.1\] Video encoding tools](#)
 - [\[5.3.2\] Audio encoding tools](#)
 - [\[5.3.3\] Other production tools](#)
 - [\[5.3.4\] Other production services](#)
 - [\[5.4\] What DVD authoring systems are available?](#)
 - [\[5.5\] Who can produce a DVD for me?](#)
 - [\[5.6\] What testing/verification services and tools are available?](#)
 - [\[5.7\] Can I put DVD-Video content on a CD-R or CD-RW?](#)
 - [\[5.8\] How do I copy my home videos/movies/slides to DVD?](#)
 - [\[5.9\] How can I copy a DVD?](#)
 - [\[5.9.1\] What's with those "Copy any DVD" e-mails?](#)

- [\[5.10\] How do I get a job making DVDs?](#)
- [\[5.11\] Where can I get DVD training?](#)
- [\[5.12\] How can I sell DVDs that I made?](#)
- [\[5.13\] How do I put a PowerPoint presentation on DVD?](#)
- [\[6\] Miscellaneous](#)
 - [\[6.1\] Who invented DVD and who owns it? Whom to contact for specifications and licensing?](#)
 - [\[6.2\] Who is making or supporting DVD products?](#)
 - [\[6.2.1\] Consumer electronics](#)
 - [\[6.2.2\] Studios, video publishers, and distributors](#)
 - [\[6.2.3\] Hardware and computer components](#)
 - [\[6.2.4\] Computer software titles on DVD-ROM](#)
 - [\[6.3\] Where can I buy \(or rent\) DVDs and players?](#)
 - [\[6.3.1\] Where can I buy blank recordable DVDs?](#)
 - [\[6.4\] Where can I get more information about DVD?](#)
 - [\[6.4.1\] A few of the top DVD info sites](#)
 - [\[6.4.2\] DVD utilities and region-free information](#)
 - [\[6.4.3\] Information and discussion groups for DVD authors](#)
 - [\[6.4.4\] DVD info for specific regions](#)
 - [\[6.4.5\] DVD info in other languages](#)
 - [\[6.4.6\] Books about DVD](#)
 - [\[6.5\] What's new with DVD technology?](#)
- [\[7\] Leftovers](#)
 - [\[7.1\] Unanswered questions](#)
 - [\[7.2\] Notation and units](#)
 - [\[7.3\] Acknowledgments](#)

Recent changes (last posted to newsgroups on Feb 9):

- 2004-11-15: Note about VMD ([6.5](#)).
- 2004-11-15: Minor corrections to CSS section ([1.11](#)).
- 2004-11-01: Over 40,000 DVD titles are now available ([1.6](#)).
- 2004-10-23: Updated info on next-gen formats ([3.13](#)).
- 2004-10-23: Improved PAL/NTSC information. List of major countries/regions and link to a list at remoteviewing.com ([1.19](#)).
- 2004-10-22: Link DVDEnFrancais ([6.4.5](#)).
- 2004-09-13: Link to list of film transfer services at HomeMovieDay.com ([5.8](#)).

- 2004-09-05: Note about problems from multiple DVD players installed ([4.6](#)).
- 2004-09-03: New German translation ([0.1](#)).
- 2004-08-29: New question:
[\[4.3.11\] What does 2x, 4x, 16x, and so on mean on recordable discs, and which one should I use?](#)
- 2004-08-29: Updated info on DVD writing speeds ([4.2](#)).
- 2004-08-16: New question:
[\[1.12.1\] What's the difference between DVD-Audio discs and DVD-Music discs?](#)
- 2004-08-16: Renamed [1.12](#) to "What about music on DVD: DVD-Audio and SACD?"
- 2004-08-13: Added DTS to list of licensors ([6.1](#)).
- 2004-07-27: Updated DVD release stats ([1.6](#)).
- 2004-07-27: Latest guidelines on logo licensing ([6.1](#)).
- 2004-07-23: Updated licensing fees ([6.1](#)).
- 2004-07-19: A bit more info on HDMI for digital audio output ([3.1](#)).
- 2004-07-01: Note about poorly mixed dialog tracks ([3.6.5](#)).
- 2004-05-26: Updated licensing info ([6.1](#)).
- 2004-04-26: Clarified encoding of progressive vs. interlaced source ([3.4](#)).
- 2004-04-16: Fixed dozens of outdated links, removed dozens of dead links.
- 2004-04-16: Defined NBCA ([3.11](#)).
- 2004-04-15: Minor revisions and updated links on longevity info ([3.12](#)).
- 2004-04-14: New question:
[\[3.6.5\] Why is the dialog hard to hear?](#)
- 2004-04-14: Additions to 2-channel audio hookup instructions ([3.2](#)).
- 2004-03-21: Added disc write time column to table of drive speeds ([4.2](#)).
- 2004-03-21: New information on HD formats ([3.13](#)).
- 2004-03-21: Minor additions to D-VHS info ([2.17](#)).
- 2004-03-17: Revised [1.27](#) and renamed it to "Why does playback sometimes freeze for a second?"
- 2004-02-22: Links to the Laserdisc Database ([2.6](#) and [2.7](#)).
- 2004-02-15: Link to Robert's DVD Info pages at their new home ([6.4.1](#)).
- 2004-02-09: Removed CopyLeft T-shirt link since the site is apparently taking orders but not fulfilling them ([4.8](#)).
- 2004-02-07: Removed dead link and added Widescreen Museum link ([3.5](#)).
- 2004-02-07: Pointer to DVDRHelp.com to find players that can play MP3 DVDs ([2.4.12](#)).
- 2004-02-07: Listed more optional features (MP3 DVDs, DivX, etc.) ([1.2](#)).
- 2004-01-24: Link to DVD compatibility report ([4.3.1](#)).
- 2004-01-24: Link to NIST guides to disc care ([1.39](#)).
- 2004-01-24: Updates on DivX, 3ivx, and XviD ([2.10](#)).
- 2004-01-24: A few updates to "laser rot" section ([1.24](#)).

- 2004-01-24: Added a little historical context to laserdisc section ([2.6](#)).
 - 2004-01-23: A bit more on video and audio problems. ([3.2.2](#))
 - 2004-01-13: Link to new French translation. ([0.1](#))
 - 2004-01-12: Added note about recordable incompatibility to playback problems. ([1.41](#))
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[0] Where can I get the DVD FAQ?

- The most current version is on the Web at <dvddemystified.com/dvdfaq.html>.
- A text version is posted periodically as "rec.video.dvd Frequently Asked Questions (FAQ)" to rec.video.dvd.tech, rec.video.dvd.misc, rec.answers, news.answers, and other relevant newsgroups. You can also get a text version of the FAQ by using the "Save As..." feature of your browser.
- Official mirror copy locations:
 - U.S. (Digital Bits) <www.thedigitalbits.com/officialfaq.html>
 - U.S. (Home Theater Forum) <www.hometheaterforum.com/bbs/faq/faq.html>
 - U.S. (DVD Review) <www.dvdreview.com/faq/dvdfaq.shtml>
 - UK (DVD Reviewer) <www.dvdreviewer.co.uk/info/recfaq.asp>
 - UK (DVDAnswers) <www.dvdanswers.com/index.php?r=0&s=31>
 - Germany (Area DVD) <www.areadvd.de/dvdfaq.html>
 - Out of date: Netherlands (DVD-Info Point) <www.dvdfaq.nl/dvdfaq/faquk.html>
 - Out of date: Norway (DVDnett.no) <www.dvdnett.no/dvdfaq>
 - Out of date: DVD City <www.dvdcity.com/officialfaq.html> (optimized by Adero for faster access in Australia France, Germany, Hong Kong, Japan, Netherlands, Singapore, Spain)
 - Out of date: Australia (aus.dvd) <members.ozemail.com.au/~brierley/dvd/FAQ.html>
- A text archive of the version last posted to newsgroups is at <www.fags.org/fags/rec-video/dvd-faq> and other FAQ mirrors, as well as <www.dvddemystified.com/dvdfaq.txt>.

[0.1] Has the DVD FAQ been translated into other languages?

The following translations of the DVD FAQ are available. Translations to a few other languages are in progress.

- Chinese <dvdfaq.126.com>. *Míngxìè* to Wu Lingchao.
- German <www.dvdfaq.de.vu>. *Tausend Dank* to Carsten Stupka.
- French <perso.club-internet.fr/fernould/dvdfaqvf.html>. *Merci beaucoup* to Franck Ernould. (An [old French translation](#) by Zahir Abela is still available.)
- Hungarian <www.dvdcenter.hu/dvdfaq.html>. *Köszönöm szépen* to Ferenc Fellner.
- Italian <digilander.iol.it/pierugo1/traduzione_faq_dvd.html>. *Molti ringraziamenti* to Pierugo Mazzaccheri.
- Japanese <http://discaid.co.jp/dvd/dvdfaq_j.html>. *Otsukaresama* to Yoshida Toshinori.
- Korean <www.dvdprime.com/dvdfaq_kor.html>. *Gamsahamnida* to Park, Jin Hong.
- Norwegian <www.dvdnett.no/dvdfaq/norsk/>. *Tusen takk* to Paul H. Brekke and Lasse Hatletvedt.
- Russian <<http://www.rusdvd.com/dvdfaq>>. *Spasibo bolshoye* to Alexander Lokshin.

- Spanish <club.idecnet.com/~modegar/video/dvdfaq.html>. *Muchisimas gracias* to Modesto Garrido.
- Turkish (portions only) <www.film.gen.tr/dvd/dvdfaqtr.cfm>. *Cok tesekkurler* to Bilgehan Marap.

If you'd like to translate the DVD FAQ into another language (Klingon, anyone?), please contact [Jim](#).

Also see [6.4.5](#) for DVD info in other languages.

[0.2] This FAQ is too long and technical. Is there a simpler version?

Take a gander at [Earl's Famous DVD Technology Exposition Web Page Extravaganza Supreme Deluxe](#) <lonestar.texas.net/~bdub/earl/dvd.htm>.

Or you might prefer [The Simpsons' DVD Q&A](#). (Although Lisa erroneously claims DVD stands for "digital versatile disc" -- who you gonna believe, me or an 8-year old genius?)

[0.3] Is this FAQ any good? Who wrote it? How do I know it's accurate?

Here are a few [user comments](#) on the DVD FAQ. It's the most accurate source of DVD information in this galaxy. If you find something you think is in error, please [let Jim know](#). There's plenty of other good information about DVD on the Internet. Pointers to other DVD sites are scattered throughout the FAQ and in section [6.4](#).

The DVD FAQ is written by Jim Taylor, the author of [DVD Demystified](#) and [Everything You Ever Wanted to Know About DVD](#). Jim has been in the DVD business since before there was a DVD business. He found out about the upcoming DVD format in 1995 and began writing articles to let others know about this amazing new technology. Jim received the 2000 DVD Pro Discus Award for Outstanding Contribution to the Industry, was named one of the 21 most influential DVD executives by DVD Report, was an inaugural inductee into the 2002 Digital Media Hall of Fame, and was named one of the Pioneers of DVD in the October 2003 issue of One to One magazine. Jim has worked with interactive media for over 20 years, developing educational software, laserdiscs, CD-ROMs, Web sites, and DVDs, along with teaching workshops, seminars, and university courses. He writes articles and columns about DVD for publications such as [Widescreen Review](#), serves as President of the [DVD Association](#), and sits on advisory boards of leading-edge companies in the DVD industry. Jim was formerly DVD Evangelist at Microsoft, and is currently Chief of DVD Technology and General Manager of the Advanced Technology Group at [Sonic Solutions](#), the leading developer of DVD authoring systems.

[0.4] How big is this thing?

Since you asked, here are the stats as of Oct, 2002:

Size: 538 KB (551,169 bytes)

Number of words: 64,016

Number of external links: 2,776

If you're wondering why it's all in one big piece instead of broken into smaller pieces that would load faster, the main reason is so you can use the find feature of your browser to easily search the entire FAQ. I realize this causes problems with WebTV browsers. Sorry. I might break it up some day. In the meantime, try this [advice](#).

[1] General DVD

[1.1] What is DVD?

DVD is the new generation of optical disc storage technology. DVD is essentially a bigger, faster CD that can hold cinema-like video, better-than-CD audio, still photos, and computer data. DVD aims to encompass home entertainment, computers, and business information with a single digital format. It has replaced laserdisc, is well on the way to replacing videotape and video game cartridges, and could eventually replace audio CD and CD-ROM. DVD has widespread support from all major electronics companies, all major computer hardware companies, and all major movie and music studios. With this unprecedented support, DVD became the most successful consumer electronics product of all time in less

than three years of its introduction. In 2003, six years after introduction, there were over 250 million DVD playback devices worldwide, counting DVD players, DVD PCs, and DVD game consoles. This was more than half the numbers of VCRs, setting DVD up to become the new standard for video publishing.

It's important to understand the difference between the *physical formats* (such as DVD-ROM and DVD-R) and the *application formats* (such as DVD-Video and DVD-Audio). DVD-ROM is the base format that holds data. DVD-Video (often simply called DVD) defines how video programs such as movies are stored on disc and played in a DVD-Video player or a DVD computer (see [4.1](#)). The difference is similar to that between CD-ROM and Audio CD. DVD-ROM includes recordable variations: DVD-R/RW, DVD-RAM, and DVD+R/RW (see [4.3](#)). The application formats include DVD-Video, DVD-Video Recording (DVD-VR), DVD+RW Video Recording (DVD+VR), DVD-Audio Recording (DVD-AR), DVD Stream Recording (DVD-SR), DVD-Audio (DVD-A), and Super Audio CD (SACD). There are also special application formats for game consoles such as Sony PlayStation 2 and Microsoft Xbox.

[1.1.1] What do the letters DVD stand for?

All of the following have been proposed as the words behind the letters DVD.

- Delayed, very delayed (referring to the many late releases of DVD formats)
- Diversified, very diversified (referring to the proliferation of recordable formats and other spinoffs)
- Digital venereal disease (referring to piracy and copying of DVDs)
- Dead, very dead (from naysayers who predicted DVD would never take off)
- Digital video disc (the original meaning proposed by some of DVD's creators)
- Digital versatile disc (a meaning later proposed by some of DVD's creators)
- Nothing

And the official answer is? "Nothing." The original acronym came from "digital video disc." Some members of the DVD Forum (see [6.1](#)) tried to express that DVD goes far beyond video by retrofitting the painfully contorted phrase "digital versatile disc," but this has never been officially accepted by the DVD Forum as a whole. The DVD Forum decreed in 1999 that DVD, as an international standard, is simply three letters. After all, how many people ask what VHS stands for? (Guess what, no one agrees on that one either.)

[1.2] What are the features of DVD-Video?

- Over 2 hours of high-quality digital video (a double-sided, dual-layer disc can hold about 8 hours of high-quality video, or 30 hours of VHS quality video).
- Support for widescreen movies on standard or widescreen TVs (4:3 and 16:9 aspect ratios).
- Up to 8 tracks of digital audio (for multiple languages, commentaries, etc.), each with as many as 8 channels.
- Up to 32 subtitle/karaoke tracks.
- Automatic seamless branching of video (for multiple story lines or ratings on one disc).
- Up to 9 camera angles (different viewpoints can be selected during playback).
- On-screen menus and simple interactive features (for games, quizzes, etc.).
- Multilingual identifying text for title name, album name, song name, cast, crew, etc.
- Instant rewind and fast forward (no "be kind, rewind" stickers and threats on rental discs)
- Instant search to title, chapter, music track, and timecode.
- Durable (no wear from playing, only from physical damage).
- Not susceptible to magnetic fields. Resistant to heat.
- Compact size (easy to handle, store, and ship; players can be portable; replication is cheaper than tapes or laserdiscs).

- Noncomedogenic.

Note: Most discs do not contain all features (multiple audio/subtitle tracks, seamless branching, parental control, etc.), as each feature must be specially authored. Some discs may not allow searching or skipping.

Most players support a standard set of features:

- Language choice (for automatic selection of video scenes, audio tracks, subtitle tracks, and menus).*
- Special effects playback: freeze, step, slow, fast, and scan.
- Parental lock (for denying playback of discs or scenes with objectionable material).*
- Programmability (playback of selected sections in a desired sequence).
- Random play and repeat play.
- Digital audio output (PCM stereo and Dolby Digital).
- Recognition and output of DTS Digital Surround audio tracks.
- Playback of audio CDs.

* Must be supported by additional content on the disc.

Some players include additional features:

- Component video output (YUV or RGB) for higher quality picture.
- Progressive-scan component output (YUV or RGB) for highest quality analog picture.
- Digital video output (SDI, 1394, or DVI/HDMI) for perfect digital picture.
- Six-channel analog output from internal audio decoder (Dolby Digital, DTS, or MLP).
- Playback of Video CDs or Super Video CDs.
- Playback of MP3 CDs.
- Playback of MP3 DVDs.
- Playback of video files in other formats such as DivX and MPEG-4.
- Playback of Picture CDs and Photo CDs.
- Playback of laserdiscs and CDVs.
- Reverse single frame stepping.
- Reverse play (normal speed).
- RF output (for TVs with no direct video input).
- Multilingual on-screen display.
- Multiple disc capacity.
- Digital zoom (2x or 4x enlargement of a section of the picture). This is a player feature, not a DVD disc feature.

[1.3] What's the quality of DVD-Video?

DVD has the capability to produce near-studio-quality video and better-than-CD-quality audio. DVD is vastly superior to consumer videotape and generally better than laserdisc (see [2.7](#)). However, quality depends on many production factors. As compression experience and technology improves we see increasing quality, but as production costs decrease and DVD authoring software becomes widely available

we also see more shoddily produced discs. A few low-budget DVDs even use MPEG-1 encoding (which is no better than VHS) instead of higher-quality MPEG-2.

DVD video is usually encoded from digital studio master tapes to MPEG-2 format. The encoding process uses *lossy* compression that removes redundant information (such as areas of the picture that don't change) and information that's not readily perceptible by the human eye. The resulting video, especially when it is complex or changing quickly, may sometimes contain visual flaws, depending on the processing quality and amount of compression. At average video data rates of 3.5 to 6 Mbps (million bits/second), *compression artifacts* may be occasionally noticeable. Higher data rates can result in higher quality, with almost no perceptible difference from the master at rates above 6 Mbps. As MPEG compression technology improves, better quality is being achieved at lower rates.

Video from DVD sometimes contains visible *artifacts* such as color banding, blurriness, blockiness, fuzzy dots, shimmering, missing detail, and even effects such as a face that "floats" behind the rest of the moving picture. It's important to understand that the term "artifact" refers to anything that is not supposed to be in the picture. Artifacts are sometimes caused by poor MPEG encoding, but artifacts are more often caused by a poorly adjusted TV, bad cables, electrical interference, sloppy digital noise reduction, improper picture enhancement, poor film-to-video transfer, film grain, player faults, disc read errors, and so on. Most DVDs exhibit few visible MPEG compression artifacts on a properly configured system.. If you think otherwise, you are misinterpreting what you see.

Some early DVD demos were not very good, but this is simply an indication of how bad DVD can be if not properly processed and correctly reproduced. In-store demos should be viewed with a grain of salt, since most salespeople are incapable of properly adjusting a television set.

Most TVs have the sharpness set too high for the clarity of DVD. This exaggerates high-frequency video and causes distortion, just as the treble control set too high on a stereo causes the audio to sound harsh. For best quality the sharpness control should be set very low. Brightness should also not be set too high. Some DVD players output video with a black-level setup of 0 IRE (Japanese standard) rather than 7.5 IRE (US standard). On TVs that are not properly adjusted this can cause some blotchiness in dark scenes. There may be an option in the player menu to use standard black level. DVD video has exceptional color fidelity, so muddy or washed-out colors are almost always a problem in the display (or the original source), not in the DVD player or disc.

DVD audio quality is superb. DVD includes the option of PCM (pulse code modulation) digital audio with sampling sizes and rates higher than audio CD. Alternatively, audio for most movies is stored as discrete, multi-channel surround sound using Dolby Digital or DTS audio compression similar to the digital surround sound formats used in theaters. As with video, audio quality depends on how well the processing and encoding was done. In spite of compression, Dolby Digital and DTS can be close to or better than CD quality.

[1.4] What are the disadvantages of DVD?

- Vagueness of the DVD specification and inadequate testing of players and discs has resulted in incompatibilities. Some movie discs don't function fully (or don't play at all) on some players. (See [1.41](#))
- DVD recorders are more expensive than VCRs. (See [1.14](#) and [4.3](#))
- DVD has built-in copy protection and regional lockout. (See [1.11](#) and [1.10](#))
- DVD uses digital compression. Poorly compressed audio or video may be blocky, fuzzy, harsh, or vague. (See [1.3](#))
- The audio downmix process for stereo/Dolby Surround may reduce dynamic range. (See [3.6](#))
- DVD doesn't fully support HDTV. (See [2.9](#))
- Some DVD players and drives can't read CD-Rs. (See [2.4.3](#))
- Some DVD players and drives can't read recordable DVDs. (See [4.3.1](#))
- Most DVD players and drives can't read DVD-RAM discs. (See [4.3.4](#))
- Very few players can play in reverse at normal speed.

- Variations and options such as DVD-Audio, DVD-VR, and DTS audio tracks are not supported by all players.

[1.5] What DVD players and drives are available?

Some manufacturers originally announced that DVD players would be available as early as the middle of 1996. These predictions were woefully optimistic. Delivery was initially held up for "political" reasons of copy protection demanded by movie studios, but was later delayed by lack of titles. The first players appeared in Japan in November, 1996, followed by U.S. players in March, 1997, with distribution limited to only 7 major cities for the first 6 months. Players slowly trickled in to other regions around the world. Prices for the first players in 1997 were \$1000 and up. By the end of 2000, players were available for under \$100 at discount retailers. In 2003 players became available for under \$50. Six years after the initial launch, close to one thousand models of DVD players were available from over a hundred consumer electronics manufacturers (see [6.2](#)).

Fujitsu supposedly released the first DVD-ROM-equipped computer on Nov. 6 in Japan. Toshiba released a DVD-ROM-equipped computer and a DVD-ROM drive in Japan in early 1997 (moved back from December which was moved back from November). DVD-ROM drives from Toshiba, Pioneer, Panasonic, Hitachi, and Sony began appearing in sample quantities as early as January 1997, but none were available before May. The first PC upgrade kits (a combination of DVD-ROM drive and hardware decoder card) became available from Creative Labs, Hi-Val, and Diamond Multimedia in April and May of 1997.

Today, every major PC manufacturer has models that include DVD-ROM drives. The price difference from the same system with a CD-ROM drive ranges from \$30 to \$200 (laptops have more expensive drives). Upgrade kits for older computers have been available over the years for \$100 to \$700 from companies such as [Creative Labs](#), [DynaTek](#), E4 (Elecede), [Hi-Val](#), [Leadtek](#), [Margi Systems](#) (for laptops), [Media Forte](#), [Pacific Digital](#), [Sigma Designs](#), [Sony](#), [Toshiba](#), [Utopia](#), and others. For more information about DVDs on computers, including writable DVD drives, see [section 4](#).

Note: If you buy a player or drive from outside your country (e.g., a Japanese player for use in the US) you may not be able to play region-locked discs on it. (See [1.10](#).)

The first DVD-Audio players were released in Japan by Pioneer in late 1999, but they did not play copy-protected discs. Matsushita (under the Panasonic and Technics labels) first released full-fledged players in July 2000 for \$700 to \$1,200. DVD-Audio players are now also made by Aiwa, Denon, JVC, Kenwood, Madrigal, Marantz, Nakamichi, Onkyo, Toshiba, Yamaha, and others. Sony released the first SACD players in May 1999 for \$5,000. Pioneer's first DVD-Audio players released in late 1999 also played SACD. SACD players are now also made by Accuphase, Aiwa, Denon, Kenwood, Marantz, Philips, Sharp, and others. (See [1.12](#) for more information on DVD-Audio and SACD.)

More information on players and drives:

- CNET [DVD players](#) and [DVD-ROM drives](#)
- The [uk.media.dvd FAQ](#).
- [aus.dvd](#) (Australia/New Zealand/region 4 player info)
- Computer Shopper [DVD players](#) and [DVD-ROM drives](#)

[1.5.1] Which player should I buy?

There are many good players available. Video and audio performance in all modern DVD players is excellent. Personal preferences, your budget, and your existing home theater setup all play a large role in determining which player is best for you. Unless you have a high-end home theater setup, a player that costs under \$250 should be completely adequate. Make a list of things that are important to you (such as ability to play CD-Rs, ability to play Video CDs, 96 kHz/24-bit audio decoding, DTS Digital Out, internal 6-channel Dolby Digital decoder) to help you come up with a set of players. Then try out a few of the players in your price range, focusing on ease of use (remote control design, user interface, front-panel controls). Since there is not a big variation in picture quality and sound quality within a given price range, convenience features play a big part. The remote control, which you'll use all the time, can drive you crazy if it doesn't suit your style.

Some players, especially cheaper models, don't properly play all discs. Before buying a player, you may want to test it with a few complex discs such as *The Matrix*, *The Abyss*, *Independence Day*, and *DVD Demystified*. See [1.41](#) for more information.

In certain cases, you might want to buy a DVD PC instead of a standard DVD player, especially if you want progressive video. See [1.40](#) and [4.1](#).

Here are a few questions to ask yourself.

- Do I want selectable sound tracks and subtitles, multiangle viewing, aspect ratio control, parental/multirating features, fast and slow playback, great digital video, multichannel digital audio, compatibility with Dolby Pro Logic receivers, on-screen menus, dual-layer playback, and ability to play audio CDs? This is a trick question, since all DVD players have all of these features.
- Do I want DTS audio? If so, look for a player with the "DTS Digital Out" logo. (See [3.6.2](#).)
- Do I want to play Video CDs? If so, check the specs for Video CD compatibility. (See [2.4.5](#).)
- Do I want to play recordable DVDs? If so, check the specs or compatibility reports for ability to read -R, -RW, +R, and +RW formats. (See [4.3.1](#).)
- Do I need a headphone jack?
- Do I want player setup menus in languages other than English? If so, look for a multilanguage setup feature. (Note: all players support on-disc multilanguage menus.)
- Do I want to play homemade CD-R audio discs? If so look for the "dual laser" feature. (See [2.4.3](#).)
- Do I want to replace my CD player? If so, you might want a changer that can hold 3, 5, or even hundreds of discs.
- Do I want to play discs from other countries? If so, beware of regions (see [1.10](#)) and TV formats (see [1.19](#)).
- Do I want to control all my entertainment devices with one remote control? If so, look for a player with a programmable universal remote, or make sure your existing universal remote is compatible with the DVD player.
- Do I want to zoom in to check details of the picture or get rid of the black letterbox bars? If so, look for players with picture zoom.
- Do I have a DTV or progressive-scan display? If so, get a progressive-scan player. (See [1.40](#).)
- Do I want to play HDCDs? If so, check for the HDCD logo. (See [2.4.13](#).)
- Does my receiver have only optical or only coax digital audio inputs? If so, make sure the player has outputs to match. (See [3.2](#).)
- Do I care about black-level adjustment?
- Do I value special deals? If so, look for free DVD coupons and free DVD rentals that are available with many players.

For more information, read hardware reviews at Web sites such as [DVDFile](#) or in magazines such as [Widescreen Review](#). You may also want to read about user experiences at [Audio Review](#) and in online forums at [Home Theater Forum](#) and [DVDFile](#). There's more advice at [DVDBuyingGuide](#) and at [eCoustics.com](#), which also has a list of links to reviews on other sites.

See sections [3.1](#) and [3.2](#) for specific information on what audio/video connections are needed to fit into your existing setup.

[1.6] What DVD titles are available?

[In the video distribution industry, a *title* refers to a movie or other production release, like *Snow White*, or *Star Wars*, or a boxed edition of a TV series, like *Babylon 5 First Season*. Titles are collectively referred to as *software*, not to be confused with computer software.]

DVD started off slowly. Rosy predictions of hundreds of movie titles for Christmas of 1996 failed to materialize. Only a handful of DVD titles, mostly music videos, were available in Japan for the November 1996 launch of DVD. The first feature films on DVD appeared in Japan on December 20 (*The Assassin*, *Blade Runner*, *Eraser*, and *The Fugitive* from Warner Home Video). By April there were over 150 titles in Japan. The first titles released in the U.S., on March 19, 1997, by Lumivision, authored by AIX Entertainment, were IMAX adaptations: *Africa: The Serengeti*, *Antarctica: An Adventure of a Different Nature*, *Tropical Rainforest*, and *Animation Greats*. (Other movies such as *Batman* and *Space Jam* had been demonstrated earlier, but were not full versions available for sale.) The Warner Bros. U.S. launch followed on March 24, but was limited to seven cities. Almost 19,000 discs were purchased in the first two weeks of the US launch -- more than expected. InfoTech predicted over 600 titles by the end of 1997 and more than 8,000 titles by 2000. By December 1997, over 1 million individual DVD discs were shipped, representing about 530 titles. By the end of 1999, over 100 million discs had shipped, representing about 5,000 titles. By the end of 2000 there were over 10,000 titles available in the US and over 15,000 worldwide. By the end of 2001 there were about 14,000 titles available in the U.S. By the end of 2002 there were about 23,000 titles available in the U.S. Compared to other launches (CD, LD, etc.) these are a huge numbers of titles released in a very short time. (Note that this does not include adult titles, which accounts for an additional 15% or so.) By mid 2004, there were about 35,000 titles available in the U.S. It would cost you just under \$800,000 to buy one copy of each. In fall 2004, DVD titles passed 40,000. By March 2003, six years after launch, over 1.5 billion copies of DVD titles had been shipped.

A number of DVD launches in Europe were announced with little follow-through, but DVD began to become established in Europe around the end of 1998. Availability of DVD software in Europe was initially about 18 months to a year behind the U.S., but has shortened over the years to a delay of only a few weeks to a few months.

See [6.3](#) for a list of Web sites where you can buy or rent DVDs.

There are many databases on the Internet to search for DVD titles. Here are a few of the best:

- Internet Movie Database [DVD Browser](#) (all regions)
- Doug MacLean's [Home Theater Info](#) list (region 1, downloadable list)
- [DVD Entertainment Group](#) (region 1, searchable and downloadable database)
- [Widescreen Review](#) (widescreen-specific DVD titles)
- Most Internet DVD stores also have searchable lists (see [6.3](#)).

DVD-Audio started even slower than DVD-Video. The first commercially available DVD-Audio title, *Big Phat Band*, was released in October 2000 by on the Silverline label of 5.1 Entertainment. Major music labels BMG Entertainment, EMI Music, Universal Music, and Warner Music have committed to DVD-Audio titles, although in fall 2001 Universal announced that it would release SACD titles first. As of the end of 2001, just under 200 DVD-Audio titles were available. The first SACD titles were released in Japan in May 1999.

DVD-ROM computer software is slowly appearing. Many initial DVD-ROM titles were only available as part of a hardware or software bundle. IDC predicted that over 13 percent of all software would be available in DVD-ROM format by the end of 1998, but reality didn't meet expectations. In one sense, DVD-ROMs are simply larger faster CD-ROMs and contain the same material. In many cases CD-ROMs are big enough that there's no need to move to DVD-ROMs. But DVD-ROMs can also take advantage of the high-quality video and multi-channel audio capabilities being added to many DVD-ROM-equipped computers.

[1.6.1] Where can I read reviews of DVDs?

The following sites have reviews of at least 800 discs. Also see the list of [DVD review sites](#) at Yahoo.

- [The Big Picture](#)
- [BinaryFlix](#) (menu pictures included with every review)
- [The Cinema Laser](#)
- [DigitalAudioVideo.com](#)
- [The Digital Bits](#)
- [DVD Authority](#)

- [DVD File](#)
- [DVD Review](#)
- [DVD Talk](#)
- [DVD Verdict](#)
- [The Laser Examiner](#)
- [Widescreen Review Magazine](#) (widescreen movies only)

[1.6.2] How do I find out when a movie or TV show will be available on DVD?

First, check one of the lists and databases mentioned in [1.6](#) to make sure it's not already available. Then check the upcoming release lists at [DVD Review](#) and [Laser Scans](#). There's also the release list at [Image Entertainment](#). A good source of info about unannounced titles is The Digital Bits [Rumor Mill](#).

[1.6.3] Why isn't my favorite movie on DVD?

There are many factors that determine when a title is released on DVD. Sometimes the director or producer has control over DVD/video release. Other times it's up to the studio marketing group. Often there are issues with rights. For example, a DVD might be available in one country or region but not available in another because different studios have distribution rights in different countries. Studios do listen to customers, so let them know what titles you'd like to see (see [6.2.2](#)).

[1.6.4] How can I find DVDs with specific features or characteristics?

Use one of the searchable databases in [1.6](#). Select the features you're looking for (anamorphic widescreen, French audio track, Flemish subtitles, and so on). If a database doesn't include the characteristic you're looking for, try a different database.

[1.6.5] Why do some rental stores and retailers not carry widescreen DVDs?

Some rental chains such as Blockbuster and retailers such as Wal-Mart originally carried only fullscreen (pan and scan) versions of movies when both widescreen and fullscreen versions were available. This infuriated many DVD fans, who could never countenance watching a non-widescreen version of a movie on DVD. There was much complaining, including an [online petition](#) with over 25,000 signatures. In early 2003 Blockbuster reversed their policy with the following statement: "We made a decision to purchase the majority of titles we bring in on DVD in the widescreen format. We try to follow our customer preferences. As DVD becomes increasingly popular, they become more familiar with the features and with the benefits of letterboxing. They've learned it's a superior format to full-frame." Wal-Mart similarly switched to widescreen versions apparently after realizing that they sold better.

See [3.5](#) for more about widescreen. See [1.38](#) for pros and cons of letterboxing.

[1.7] How much do players and drives cost?

Mass-market DVD movie players list for \$40 to \$3000. (See [1.5](#) for more information.) DVD-ROM drives and upgrade kits for computers sell for around \$30 to \$400. (OEM drive prices are around \$40.)

[1.8] How much do discs cost?

It varies, but most DVD movies list for \$20 to \$30 with street prices between \$15 and \$25, even those with supplemental material. Low-priced movies can be found for under \$10. DVDs have not followed the initial high-rental-price model of VHS.

DVD-ROMs are usually slightly more expensive than CD-ROMs since there is more on them, they cost a bit more to replicate, and the market is smaller. But as the installed base of drives grow, DVD-ROMs will eventually cost about the same as CD-ROMs do today.

The following sites help you find the lowest prices and discount coupons:

- [BargainFlix](#)
- [DVD Price Search](#)

[1.9] How is DVD doing? Where can I get statistics?

DVD did not take off quite as fast as some early predictions, but it has sold faster than videotape, CD, and laserdisc. In fact, before its third birthday in March 2000, DVD had become the most successful consumer electronics entertainment product ever.

Here are some predictions:

- InfoTech (1995): Worldwide sales of DVD players in 1997 will be 800,000. Worldwide sales of DVD-ROM drives in 1997 will be 1.2 million, with sales of 39 million drives in 2000.
- Toshiba (1996): 100,000 to 150,000 DVD-Video players will be sold in Japan between Nov. 1 and Dec. 31, 1996, and 750,000-1 million by Nov. 1, 1997. (Actual count of combined shipments by Matsushita, Pioneer, and Toshiba was 70,000 in Oct-Dec 1996.) Total worldwide DVD hardware market expected to reach 120 million units in the year 2000. Worldwide settop DVD player market will be 2 million units in the first year, with sales of 20 million in the year 2000.
- Pioneer (1996): 400,000 DVD-Video players in 1996, 11 million by 2000. 100,000 DVD-Audio players in 1996, 4 million by 2000.
- InfoTech (1996): 820,000 DVD-Video players in first year, 80 million by 2005.
- CEMA (1997): 400,000 DVD-Video players in U.S. in 1997, 1 million in 1998.
- Time-Warner (1996): 10 million DVD players in the U.S. by 2002.
- Paul Kagan (1997): 800,000 DVD players in the U.S. in 1997, 10 million in 2000, and 40 million in 2006 (43% penetration). 5.6 million discs sold in 1997, 172 million discs in 2000, and 623 million in 2006.
- C-Cube (1996): 1 million players and drives in 1997.
- BASES: 3 million DVD-Video players sold in first year, 13 million sold in 6th year.
- Dataquest (1997): over 33 million shipments of DVD players and drives by 2000.
- Philips (1996): 25 million DVD-ROM drives worldwide by 2000 (10% of projected 250 million optical drives).
- Pioneer (1996): 500,000 DVD-ROM drives sold in 1997, 54 million sold in 2000.
- Toshiba (1996): 120 million DVD-ROM drives in 2000 (80% penetration of 100 million PCs). Toshiba says they will no longer make CD-ROM drives in 2000.
- IDC (1997): 10 million DVD-ROM drives sold in 1997, 70 million sold in 2000 (surpassing CD-ROM), 118 million sold in 2001. Over 13% of all software available on DVD-ROM in 1998. DVD recordable drives more than 90% of combined CD/DVD recordable market in 2001.
- AMI (1997): installed base of 7 million DVD-ROM drives by 2000.
- Intel (1997): 70 million DVD-ROM drives by 1999 (sales will surpass CD-ROM drives in 1998).
- SMD (1997): 100 million DVD-ROM/RAM drives shipped in 2000.
- Microsoft (Peter Biddle, 1997): 15 million DVD PCs sold in 1998, 50 million DVD PCs sold in 1999.
- Microsoft (Jim Taylor, 1998): installed base of 35 million DVD PCs in 1999.
- Forrester Research (1997): U.S. base of 53 million DVD-equipped PCs by 2002. 5.2% of U.S. households (5 million) will have a DVD-V player in 2002; 2% will have a DVD-Audio player.
- Yankee Group (Jan 1998): 650,000 DVD-Video players by 1998, 3.6 million by 2001. 19 million DVD-PCs by 2001.
- InfoTech (Jan 1998): 20 million DVD-Video players worldwide in 2002, 58 million by 2005. 99 million DVD-ROM drives worldwide in 2005. No more than 500 DVD-ROM titles available by the end of 1998. About 80,000 DVD-ROM titles available by 2005.

- Screen Digest (Dec 1998): 125,000 DVD-Video player in European homes in 1998, 485,000 in 1999, 1 million in 2000.
- IRMA (Apr 2000): 12 million players will ship worldwide in 2000.
- Baskerville (Apr 2000): Worldwide spending on DVD software will surpass that of VHS by 2003. There will be a worldwide installed base of 625 million DVD players by 2010 (55% of TV households).
- Jon Peddie (Jun 2000): Almost 20 million DVD players will be sold in the U.S. in 2004.
- IDC (July 2000): 70 million DVD players and drives will be sold by year's end.
- Screen Digest (June 2000): European installed base of DVD-Video players (1998) 0.3m; (1999) 1.5m; (2000) 5.4m; (2003) 47.1m.
- Japanese Electronics and Information Technologies Association (December 2000): 37 million DVD players worldwide by 2001.
- DVD Entertainment Group (July 2001): Approximately 30 million DVD players sold in the U.S. by the end of 2001.
- Understanding & Solutions (April 2002): DVD player penetration in the UK could grow to 70% by 2006 (CD player penetration reached only 50% in the same time period after launch).

Here's reality:

- 1997
 - 349,000 DVD-Video players shipped in the U.S. (About 200,000 sold into homes.)
 - 900 DVD-Video titles available in the U.S. Over 5 million copies shipped; about 2 million sold.
 - Over 500,000 DVD-Video players shipped worldwide.
 - Around 330,000 DVD-ROM drives shipped worldwide with about 1 million bundled DVD-ROM titles.
 - 60 DVD-ROM titles (mostly bundled).
- 1998
 - 1,089,000 DVD-Video players shipped in the U.S. (Installed base of 1,438,000.)
 - 400 DVD-Video titles in Europe (135 movie and music titles).
 - 3,000 DVD-Video titles in the U.S. (2000 movie and music titles).
 - 7.2 million DVD-Video discs purchased.
- 1999
 - 4,019,000 DVD-Video players shipped in the U.S. (Installed base of 5,457,000.)
 - Over 6,300 DVD-Video titles in the U.S.
 - About 26 million DVD-ROM drives worldwide.
 - About 75 DVD-ROM titles available in the U.S.
- 2000
 - 8.5 million DVD-Video players shipped in the U.S. (Installed base of 13,922,000.)
 - About 46 million DVD-ROM drives worldwide.
 - Over 10,000 DVD-Video titles available in the U.S.

- Belgium: 100 thousand installed base
- France: 1.2 million installed base
- Germany: 1.2 million installed base
- Italy: 360 thousand installed base
- Netherlands: 200 thousand installed base
- Spain: 300 thousand installed base
- Sweden: 120 thousand installed base
- Switzerland: 250 thousand installed base
- UK: 1 million installed base
- 2001
 - 12.7 million DVD-Video players shipped in the U.S. (Installed base of 26,629,000.)
 - Over 45 million DVD-ROM drives in the U.S.
 - Over 90 million DVD-ROM drives worldwide.
 - UK: 3 million installed base
- 2002
 - 17 million DVD-Video players shipped in the U.S. (Installed base of 43,718,000.)
 - Over 75 million DVD-ROM drives in the U.S.
 - Over 140 million DVD-ROM drives worldwide.
- 2003 (fall)
 - 16 million DVD-Video players shipped in the U.S. (Installed base of 73,300,000.)
 - Over 27,000 DVD-Video titles available in the U.S.

For comparison, there were about 700 million audio CD players and 160 million CD-ROM drives worldwide in 1997. 1.2 billion CD-ROMs were shipped worldwide in 1997 from a base of about 46,000 different titles. There were about 80 million VCRs in the U.S. (89% of households) and about 400 million worldwide. 110,000 VCRs shipped in the first two years after release. Nearly 16 million VCRs were shipped in 1998. In 2000 there were about 270 million TVs in the U.S. and 1.3 billion worldwide. When DVD came out in 1997 there were under 3 million laserdisc players in the U.S.

For latest U.S. player sales statistics, see the [CEA page](#) at The Digital Bits. Other DVD statistics and forecasts can be found at [IRMA](#), [MediaLine](#), [Twice](#). Industry analyses and forecasts can be purchased from [Adams Media Research](#), [Alexander & Associates](#), [British Video Association](#), [Cahners In-stat](#), [Centris](#), [Datamonitor](#), [Dataquest](#), [DVD Intelligence](#), [eBrain](#), [International Data Corporation \(IDC\)](#), [InfoTech](#), [Jon Peddie Associates \(JPA\)](#), [Paul Kagan Associates](#), [Screen Digest](#), [SIMBA Information](#), [Strategy Analytics](#), [Understanding & Solutions](#) and others.

[1.10] What are "regional codes," "country codes," or "zone locks"?

Motion picture studios want to control the home release of movies in different countries because theater releases aren't simultaneous (a movie may come out on video in the U.S. when it's just hitting screens in Europe). Also, studios sell distribution rights to different foreign distributors and would like to guarantee an exclusive market. Therefore they required that the DVD standard include codes to prevent playback of certain discs in certain geographical regions. Each player is given a code for the region in which it's sold. The player will refuse to play discs that are not coded for its region. This means that a disc bought in one country may not play on a player bought in another country. Some people believe that region codes are an illegal restraint of trade, but no legal cases have established this.

Regional codes are entirely optional for the maker of a disc. Discs without region locks will play on any player in any country. It's not an encryption system, it's just one byte of information on the disc that the player checks. Some studios originally announced that only their new releases would have regional codes, but so far almost all Hollywood releases play in only one region. Region codes are a permanent part of the disc, they won't "unlock" after a period of time. Region codes don't apply to DVD-Audio, DVD-ROM, or recordable DVD (see below for more detail).

Seven regions (also called locales or zones) have been defined, and each one is assigned a number. Players and discs are often identified by their region number superimposed on a world globe. If a disc plays in more than one region it will have more than one number on the globe.

1: U.S., Canada, U.S. Territories

2: Japan, Europe, South Africa, and Middle East (including Egypt)

3: Southeast Asia and East Asia (including Hong Kong)

4: Australia, New Zealand, Pacific Islands, Central America, Mexico, South America, and the Caribbean

5: Eastern Europe (Former Soviet Union), Indian subcontinent, Africa, North Korea, and Mongolia

6: China

7: Reserved

8: Special international venues (airplanes, cruise ships, etc.)

(See the map at <www.blackstar.co.uk/help/help_dvd_regions>.)

Technically there is no such thing as a region zero disc or a region zero player. There is such thing as an all-region disc. There are also all-region players. Some players can be "hacked" using special command sequences from the remote control to switch regions or play all regions. Some players can be physically modified ("chipped") to play discs regardless of the regional codes on the disc. This usually voids the warranty, but is not illegal in most countries (since the only thing that requires player manufacturers to region-code their players is the CSS license; see [1.11](#)). Many retailers, especially outside North America, sell players that have already been modified for multiple regions, or in some cases they simply provide instructions on how to access the "secret" region change features already built into the player. As an interesting side note, on Feb. 7, 2001, NASA sent two [multiregion DVD players](#) to the International Space Station.

Extensive information about modifying players and buying region-free players can be found on the Internet (see [6.4.2](#)).

In addition to region codes, there are also differences in discs for NTSC and PAL TV systems (see [1.19](#)).

Some discs from Fox, Buena Vista/Touchstone/Miramax, MGM/Universal, Polygram, and Columbia TriStar contain program code that checks for the proper region setting in the player. (*There's Something About Mary* and *Psycho* are examples.) In late 2000, Warner Bros. began using the same active region code checking that other studios had been using for over a year. They called it "region code enhancement" (RCE, also known as REA), and it received much publicity. RCE was first added to discs such as *The Patriot* and *Charlie's Angels*. "Smart discs" with active region checking won't play on *code-free* players that are set for all regions (FFh), but they can be played on manual *code-switchable* players that allow you to use the remote control to change the player's region to match the disc. They may not work on *auto-switching* players that recognize and match the disc region. (It depends on the default region setting of the player. An RCE disc has all its region flags set so that the player doesn't know which one to switch to. The disc queries the player for the region setting and aborts playback if it's the wrong one. A default player setting of region 1 will fool RCE discs from region 1. Playing a region 1 disc for a few seconds sets most auto-switching players to region 1 and thus enables them to play an RCE disc.) When an RCE disc detects the wrong region or an all-region player, it will usually put up a message saying that the player may have been altered and that the disc is not compatible with the player. A serious side effect is that some legitimate players fail the test, such as the Fisher DVDS-1000.

There was much wailing and gnashing of teeth when RCE first appeared, but DVD fans quickly learned that it only affected some players. Makers of player modification kits that didn't work with RCE soon improved their chips to get around it. For every higher wall there is a taller ladder. See DVDTalk's [RCE FAQ](#) for more info and workarounds.

In general, region codes don't apply to recordable DVDs. A DVD that you make on a PC with a DVD burner or in a home DVD video recorder will play in all regions (but don't forget NTSC vs. PAL differences, see [1.19](#)). Region codes do not apply to DVD-Audio.

Regional codes apply to game consoles such as PlayStation 2 and Xbox, but only for DVD-Video (movie) discs (see [DVDRegionX](#) for region modifications to PS2). PlayStation has a separate regional lockout scheme for games. Regional codes also apply to DVD-ROM computers, but affect only DVD-Video discs,

not DVD-ROM discs containing computer software. Computer playback systems check for regional codes before playing movies from a CSS-protected DVD-Video (see [1.11](#) for CSS info). Newer *RPC2* DVD-ROM drives let you change the region code several times. (RPC stands for region protection control.) Once an *RPC2* drive has reached the limit of 5 changes it can't be changed again unless the vendor or manufacturer resets the drive. The *Drive Info* utility can tell you if you have an *RPC2* drive (it will say "This drive has region protection"). See [6.4.2](#) for links to more information about circumventing DVD-ROM region restrictions. Since December 31, 1999, only *RPC2* drives have been manufactured.

[1.11] What are the copy protection issues?

CPSA (content protection system architecture) is the name given to the overall framework for security and access control across the entire DVD family. Developed by the "[4C](#)" entity (Intel, IBM, Matsushita, and Toshiba) in cooperation with the Copy Protection Technical Working Group (CPTWG), it covers encryption, watermarking, protection of analog and digital outputs, and so on. There are many forms of content protection that apply to DVD.

1) Analog CPS (Macrovision)

Videotape (analog) copying is prevented with a [Macrovision](#) 7.0 or similar circuit in every player. Macrovision may show up as stripes of color, distortion, rolling, black & white picture, and dark/light cycling. Macrovision creates problems for most TV/VCR combos (see [3.2.1](#)) and some high-end equipment such as line doublers and video projectors.

The general term for a system that prevents taping is APS (Analog Protection System), also sometimes called copyguard. Computer video cards with composite or s-video (Y/C) output must also use APS. Macrovision changes the composite video and s-video output in two ways: the Colorstripe technique creates a rapidly modulated colorburst signal, and the AGC technique inserts pulses in the vertical blanking signal. This confuses the synchronization and automatic-recording-level circuitry in 95% of consumer VCRs. Unfortunately, it can degrade the picture, especially with old or nonstandard equipment. Macrovision was not present on analog component video output of early players, but is now required on component output (AGC only, since there is no burst in a component signal).

The discs themselves contain "trigger bits" telling the player whether or not to enable Macrovision AGC, with the optional addition of 2-line or 4-line Colorstripe. The triggers occur about twice a second, which allows fine control over what part of the video is protected. The producer of the disc decides what amount of copy protection to enable and then pays Macrovision royalties accordingly (several cents per disc). Just as with videotapes, some DVDs are Macrovision-protected and some aren't. (For a few Macrovision details see STMicroelectronics' NTSC/PAL video encoder datasheets at www.st.com/stonline/books/.)

Inexpensive devices can defeat Macrovision, although only a few work against the more recent Colorstripe feature. These devices go under names such as Video Clarifier, Image Stabilizer, Color Corrector, and [CopyMaster](#). Or you can [build your own](#). Some DVD players can be modified to turn off Macrovision output (see [6.4.2](#)). Professional time-base correctors (TBCs) that regenerate line 21 also remove Macrovision. APS affects only video, not audio.

2) CGMS

Each disc contains information specifying if the contents can be copied. This is a serial copy generation management system (SCMS) designed to prevent initial copies or generational copies (copies of copies). The CGMS information is embedded in the outgoing video signal. For CGMS to work, the equipment making the copy must recognize and respect the CGMS information. The analog standard (CGMS-A) encodes the data on NTSC line 21 (in the XDS service) or line 20. CGMS-A is recognized by most digital camcorders and by some computer video capture cards (they will flash a message such as "recording inhibited"). Professional time-base correctors (TBCs) that regenerate lines 20 and 21 will remove CGMS-A information from an analog signal. The digital standard (CGMS-D) is included in DDCP and HDMI for digital connections such as [IEEE 1394/FireWire](#). See subsections 6 and 7 below.

3) Content Scramble System (CSS)

Because of the potential for perfect digital copies, paranoid movie studios forced a deeper copy protection requirement into the DVD standard. Content Scramble System (CSS) is a data encryption and authentication scheme intended to prevent copying video files directly from DVD-Video discs. CSS was developed primarily by Matsushita and Toshiba. Each CSS player licensee is given a key from a master set of 409 keys stored on every CSS-encrypted disc. The theory was to allow a license to be revoked by removing its key from future discs. The CSS decryption algorithm exchanges keys with the drive unit to generate an encryption key that is then used to obfuscate the exchange of disc keys and title keys that are needed to decrypt data from the disc. DVD players have CSS circuitry that decrypts the data before it's decoded and displayed, and computer DVD decoder hardware and software must include a CSS

decryption module. All DVD-ROM drives have extra firmware to exchange authentication and decryption keys with the CSS module in the computer. As of 2000 DVD-ROM drives are required to support regional management in conjunction with CSS (see [1.10](#) and [4.1](#)). Makers of equipment used to display DVD-Video (drives, decoder chips, decoder software, display adapters, etc.) must license CSS. There is an annual \$15,000 fee for the CSS license, and qualification is a lengthy process, so it's recommended that interested parties apply early. CSS is administered by the [DVD Copy Control Association](#) (DVD CCA). Near the end of May 1997, CSS licenses were finally granted for software decoding. The license is extremely restrictive in an attempt to keep the CSS algorithm and keys secret. Of course, nothing that's used on millions of players and drives worldwide could be kept secret for long. In October 1999, the CSS algorithm was cracked and posted on the Internet, triggering endless controversies and legal battles (see [4.8](#)).

4) Content Protection for Prerecorded Media (CPPM)

CPPM is used only for DVD-Audio. It was developed as an improvement on CSS. Keys are stored in the lead-in area, but unlike CSS no title keys are placed in the sector headers. Each volume has a 56-bit album identifier, similar to a CSS disc key, stored in the control area. Each disc contains a media key block, stored in a file in the clear on the disc. The media key block data is logically ordered in rows and columns that are used during the authentication process to generate a decryption key from a specific set of player keys (device keys). As with CSS, the media key block can be updated to revoke the use of compromised player keys. If the device key is revoked, the media key block processing step will result in an invalid key value. The authentication mechanism is the same as for CSS, so no changes are required to existing drives. A disc may contain both CSS and CPPM content if it is a hybrid DVD-Video/DVD-Audio disc.

5) Content Protection for Recordable Media (CPRM)

CPRM is a mechanism that ties a recording to the media on which it is recorded. It is supported by some DVD recorders, but not by many DVD players. Each blank recordable DVD has a unique 64-bit media ID etched in the BCA (see [3.11](#)). When protected content is recorded onto the disc, it can be encrypted with a 56-bit C2 (Cryptomeria) cipher derived from the media ID. During playback, the ID is read from the BCA and used to generate a key to decrypt the contents of the disc. If the contents of the disc are copied to other media, the ID will be absent or wrong and the data will not be decryptable.

6) Digital Copy Protection System (DCPS)

In order to provide digital connections between components without allowing perfect digital copies, five digital copy protection systems were proposed to the [CEA](#). The frontrunner is [DTCP](#) (digital transmission content protection), which focuses on IEEE 1394/FireWire but can be applied to other protocols. The draft proposal (called 5C, for the five companies that developed it) was made by Intel, Sony, Hitachi, Matsushita, and Toshiba in February 1998. Sony released a DTCP chip in mid 1999. Under DTCP, devices that are digitally connected, such as a DVD player and a digital TV or a digital VCR, exchange keys and authentication certificates to establish a secure channel. The DVD player encrypts the encoded audio/video signal as it sends it to the receiving device, which must decrypt it. This keeps other connected but unauthenticated devices from stealing the signal. No encryption is needed for content that is not copy protected. Security can be "renewed" by new content (such as new discs or new broadcasts) and new devices that carry updated keys and revocation lists (to identify unauthorized or compromised devices). A competing proposal, XCA (extended conditional access), from Zenith and Thomson, is similar to DTCP but can work with one-way digital interfaces (such as the EIA-762 RF remodulator standard) and uses smart cards for renewable security. Other proposals have been made by MRJ Technology, NDS, and Philips. In all five proposals, content is marked with CGMS-style flags of "copy freely", "copy once," "don't copy," and sometimes "no more copies". Digital devices that do nothing more than reproduce audio and video will be able to receive all data (as long as they can authenticate that they are playback-only devices). Digital recording devices are only able to receive data that is marked as copyable, and they must change the flag to "don't copy" or "no more copies" if the source is marked "copy once." DCPSes are designed for the next generation of digital TVs, digital receivers, and digital video recorders. They require new DVD players with digital connectors (such as those on DV equipment). These new products began to appear in 2003. Since the encryption is done by the player, no changes are needed to existing discs.

7) High-Bandwidth Digital Content Protection (HDCP, DVI, and HDMI)

HDCP is similar to DTCP, but it was designed for digital video monitor interfaces. In 1998, the [Digital Display Working Group](#) (DDWG) was formed to create a universal interface standard between computers and displays to replace the analog VGA connection standard. The resulting Digital Visual Interface (DVI) specification, released in April 1999, was based on Silicon Image's PanelLink technology, which at 4.95 Gbps can support 1600×1200 (UXGA) resolution, which covers all the HDTV resolutions. Intel proposed HDCP as a security component for DVI. A new connection standard called HDMI combines DVI and HDCP. DVD players with DVI or HDMI digital video output appeared in spring 2003. Many new HDTV displays are likely to have both IEEE 1394 and HDMI connections.

HDCP provides authentication, encryption, and revocation. Specialized circuitry in the playback device and in the display monitor encrypts video data before it is sent over the link. When an HDMI output senses that the connected monitor does not support HDCP, it lowers the image quality of protected content. The HDCP key exchange process verifies that a receiving device is authorized to display or record video. It uses an array of forty 56-bit secret device keys and a 40-bit key selection vector -- all supplied by the HDCP licensing entity. If the security of a display device is compromised, its key selection vector is placed on the revocation list. The host device has the responsibility of maintaining the revocation list, which is updated by system renewability messages (SRMs) carried by newer devices and by video content. Once the authority of the receiving device has been established, the video is encrypted by an exclusive-or operation with a stream cipher generated from keys exchanged during the authentication process. If a display device with no decryption ability attempts to display encrypted content, it appears as random noise.

The first four forms of copy protection (Macrovision, CGMS, CSS, and CPPM) are optional for the producer of a disc. CSS decryption is optional for hardware and software playback manufacturers, although a player or computer without decryption capability will only be able to play unencrypted movies. CPRM is handled automatically by DVD recorders, although it's optional and many recorders don't support it. DTCP and HDCP are handled by DVD players with digital video outputs.

These copy protection schemes are designed only to guard against casual copying (which the studios claim causes billions of dollars in lost revenue). The goal is to "keep the honest people honest." The people who developed the copy protection standards are the first to admit they can't stop well-equipped pirates.

Movie studios have promoted legislation making it illegal to defeat DVD copy protection. The result is the [World Intellectual Property Organization](#) (WIPO) Copyright Treaty and the WIPO Performances and Phonograms Treaty (December 1996) and the compliant U.S. [Digital Millennium Copyright Act](#) (DMCA), passed into law in October 1998. Software intended specifically to circumvent copy protection is now illegal in the U.S. and many other countries. A co-chair of the legal group of the DVD copy protection committee stated, "in the video context, the contemplated legislation should also provide some specific assurances that certain reasonable and customary home recording practices will be permitted, in addition to providing penalties for circumvention." It's not at all clear how this might be "permitted" by a player or by studios that routinely set the "don't copy" flag on all their discs.

DVD-ROM drives and computers, including DVD-ROM upgrade kits, are required to support Macrovision, CGMS, and CSS. PC video cards with TV outputs that don't support Macrovision will not work with encrypted movies. Computers with IEEE 1394/FireWire connections must support the final DCPS standard in order to work with other DCPS devices. Likewise computers with HDMI (DVI) connections must support HDCP to output DVD-Video content. Every DVD-ROM drive must include CSS circuitry to establish a secure connection to the decoder hardware or software in the computer, although CSS can only be used on DVD-Video content. Of course, since a DVD-ROM can hold any form of computer data, other encryption schemes can be implemented. See [4.1](#) for more information on DVD-ROM drives.

The Watermarking Review Panel (WaRP) --the successor to the Data-Hiding Sub-Group (DHSG)-- of the CPTWG selected an audio watermarking system that has been accepted by the DVD Forum for DVD-Audio (see [1.12](#)). The original seven video watermarking proposals were merged into three: IBM/NEC, Hitachi/Pioneer/Sony, and Macrovision/Digimarc/Philips. On February 17, 1999, the first two groups combined to form the "Galaxy Group" and merged their technologies into a single proposal. The second group has dubbed their technology "Millennium." Watermarking permanently marks each digital audio or video frame with noise that is supposedly undetectable by human ears or eyes. Watermark signatures can be recognized by playback and recording equipment to prevent copying, even when the signal is transmitted via digital or analog connections or is subjected to video processing. Watermarking is not an encryption system, but rather a way to identify whether a copy of a piece of video or audio is allowed to be played. New players and software are required to support watermarking, but the DVD Forum intends to make watermarked discs compatible with existing players. Reports were made that the early watermarking technique used by Divx caused visible "raindrop" or "gunshot" patterns, but the problem was apparently solved for later releases.

[1.12] What about music on DVD: DVD-Audio and SACD?

Note: Don't confuse DVD-Audio with DVD-Music (see [1.12.1](#)).

When DVD was released in 1996 there was no DVD-Audio format, although the audio capabilities of DVD-Video far surpassed CD. The DVD Forum sought additional input from the music industry before defining the DVD-Audio format. A draft standard was released by the DVD Forum's Working Group 4 (WG4) in January 1998, and version 0.9 was released in July. The final DVD-Audio 1.0 specification (minus copy protection) was approved in February 1999 and released in March, but products were delayed in part by the slow process of selecting copy protection features (encryption and watermarking), with complications introduced by the Secure Digital Music Initiative (SDMI). The scheduled October 1999 release was further delayed until mid 2000, ostensibly because of concerns caused by the CSS crack (see [4.8](#)), but also because the hardware wasn't quite ready, production tools weren't up to snuff, and there was lackluster support from music labels. Pioneer released the first DVD-Audio players (without copy protection support) in Japan in late 1999.

Matsushita released Panasonic and Technics brand universal DVD-Audio/DVD-Video players in July 2000 for \$700 to \$1,200. Pioneer, JVC, Yamaha, and others released DVD-Audio players in fall 2000 and early 2001. By the end of 2000 there were about 50 DVD-Audio titles available. By the end of 2001 there were just under 200 DVD-Audio titles available.

DVD-Audio is a separate format from DVD-Video. DVD-Audio discs can be designed to work in DVD-Video players, but it's possible to make a DVD-Audio disc that won't play at all in a DVD-Video player, since the DVD-Audio specification includes new formats and features, with content stored in a separate "DVD-Audio zone" on the disc (the AUDIO_TS directory) that DVD-Video players never look at. New DVD-Audio players are needed, or new "universal players" that can play both DVD-Video and DVD-Audio discs. Universal players are also called VCAPs (video-capable audio players).

A plea to producers: Universal players are rare, but you can make **universal discs** easily. With a small amount of effort, all DVD-Audio discs can be made to work on all DVD players by including a Dolby Digital version of the audio in the DVD-Video zone.

A plea to DVD-Audio authoring system developers: Make your software do this by default or strongly recommend this option during authoring.

DVD-Audio players (and universal players) work with existing receivers. They output PCM and Dolby Digital, and some will support the optional DTS and DSD formats. However, most current receivers can't decode high-definition, multichannel PCM audio (see [3.6.1](#) for details), and even if they could it can't be carried on standard digital audio connections. DVD-Audio players with high-end digital-to-analog converters (DACs) can only be hooked up to receivers with 2-channel or 6-channel analog inputs, but some quality is lost if the receiver converts back to digital for processing. New receivers with improved digital connections such as IEEE 1394 (FireWire) are needed to use the full digital resolution of DVD-Audio.

DVD audio is copyright protected by an *embedded signaling* or *digital watermark* feature. This uses signal processing technology to apply a digital signature and optional encryption keys to the audio in the form of supposedly inaudible noise so that new equipment will recognize copied audio and refuse to play it. Proposals from Aris, Blue Spike, Cognicity, IBM, and Solana were evaluated by major music companies in conjunction with the 4C Entity, comprising IBM, Intel, Matsushita, and Toshiba. Aris and Solana merged to form a new company called Verance, whose *Galaxy* technology was chosen for DVD-Audio in August 1999. (In November 1999, Verance watermarking was also selected for SDMI.) Verance and 4C claimed that tests on the Verance watermarking method showed it was inaudible, but golden-eared listeners in later tests were able to detect the watermarking noise.

Sony and Philips have developed a competing Super Audio CD format that uses DVD discs. (See [3.6.1](#) for details.) Sony released version 0.9 of the SACD spec in April 1998, the final version appeared in April (?) 1999. SACD technology is available to existing Sony/Philips CD licensees at no additional cost. Most initial SACD releases have been mixed in stereo, not multichannel. SACD was originally supposed to provide "legacy" discs with two layers, one that plays in existing CD players, plus a high-density layer for DVD-Audio players, but technical difficulties kept dual-format discs from being produced until the end of 2000, and only then in small quantities. Pioneer, which released the first DVD-Audio players in Japan at the end of 1999, included SACD support in their DVD-Audio players. If other manufacturers follow suit, the entire SACD vs. DVD-Audio standards debate could be moot, since DVD-Audio players would play both types of discs.

Sony released an SACD player in Japan in May 1999 at the tear-inducing price of \$5,000. The player was released in limited quantities in the U.S. at the end of 1999. Philips released a \$7,500 player in May 2000. Sony shipped a \$750 SACD player in Japan in mid 2000. About 40 SACD titles were available at the end of

1999, from studios such as DMP, Mobile Fidelity Labs, Pioneer, Sony, and Telarc. Over 500 SACD titles were available by the end of 2001.

A drawback related to DVD-Audio and SACD players is that most audio receivers with 6 channels of analog input aren't able to do bass management. Receivers with Dolby Digital and DTS decoders handle bass management internally, but 6-channel analog inputs are usually passed straight through to the amplifier. Without full bass management on 6-channel analog inputs, any audio setup that doesn't have full-range speakers for all 5 surround channels will not properly reproduce all the bass frequencies.

If you are interested in making the most of a DVD-Audio or SACD player, you need a receiver with 6-channel analog audio inputs. You also need 5 full-frequency speakers (that is, each speaker should be able to handle subwoofer frequencies) and a subwoofer, unless you have a receiver that can perform bass management on the analog inputs, or you have an outboard bass management box such as from [Outlaw Audio](#).

For more on DVD-Audio, including lists of titles and player models, visit [Digital Audio Guide](#).

[1.12.1] What's the difference between DVD-Audio discs and DVD-Music discs?

DVD-Music isn't actually an official DVD format, but it has become a commonly used name for a DVD-Video disc that contains primarily music. A DVD-Music disc plays in any standard DVD player with video or still pictures that accompany the audio. As explained in [1.12](#), a DVD-Audio disc contains special high-fidelity audio tracks that can only be played in DVD-Audio players.

[1.13] Which studios support DVD?

All major movie studios and most major music labels support DVD.

When DVD players became available in early 1997, Warner and Polygram were the only major movie studios to release titles. Additional titles were available from small publishers. The other studios gradually joined the DVD camp (see [6.2](#) for a full list, see [1.6](#) for movie info). Dreamworks was the last significant studio to announce full DVD support. Paramount, Fox, and Dreamworks initially supported only Divx, but in summer 1998 they each announced support for open DVD.

[1.14] Can DVD record from TV/VCR/etc?

Yes, if you have a DVD recorder. When DVD was originally introduced in 1997, only players were available. Most DVD units sold today are still play-only, but recorders are becoming more widespread and more affordable. DVD video recorders first appeared in Japan at the end of 1999, and in the rest of the world at the end of 2000. Early units were expensive: \$2,500 to \$4,000. DVD video recorders are still quite expensive (typically \$500 to \$2000 as of mid 2003), but eventually will be as cheap as VCRs. DVD recorders are being added to satellite and cable receivers, hard-disk video recorders, and other advanced consumer electronics devices.

A DVD recorder works like a VCR -- it has a tuner and A/V inputs, and it can be programmed to record shows. An important difference is that you never have to rewind or fast forward -- recordings on a disc are instantly accessible, usually from an on-screen menu. Many DVD recorders include an electronic program guide (EPG) that gives you onscreen TV listings from which you can pick shows to record (no need to enter day, time, channel, and so on by hand).

Note that DVD video recorders can't copy most DVD movie discs, which are protected.

Unfortunately there is more than one recordable DVD format, and they don't all play together nicely. It's nothing like the old "VHS vs. Betamax battle" as many in the press would have you believe, but it is rather confusing. See [4.3](#) to get more confused.

Don't be further confused by DVD recordable drives (DVD burners) for computers (see [4.3](#)). These recorders can store data, but to create full-featured DVD-Videos requires additional software to do video encoding (MPEG), audio encoding (Dolby Digital, MPEG, or PCM), navigation and control data generation, and so on (see [5.4](#) and [5.8](#)).

[1.15] What happens if I scratch the disc? Aren't discs too fragile to be rented?

Scratches may cause minor data errors that are easily corrected. That is, data is stored on DVDs using powerful error correction techniques that can recover from even large scratches with no loss of data. A common misperception is that a scratch will be worse on a DVD than on a CD because of higher storage density and because video is heavily compressed. DVD data density (say that fast ten times!) is physically four times that of CD-ROM, so it's true that a scratch will affect more data. But DVD error correction is at least ten times better than CD-ROM error correction and more than makes up for the density increase. It's also important to realize that MPEG-2 and Dolby Digital compression are partly based on removal or reduction of imperceptible information, so decompression doesn't expand the data as much as might be assumed. Major scratches may cause uncorrectable errors that will produce an I/O error on a computer or show up as a momentary glitch in DVD-Video picture. Paradoxically, sometimes the smallest scratches can cause the worst errors (because of the particular orientation and refraction of the scratch). There are many schemes for concealing errors in MPEG video, which may be used in future players.

See [1.39](#) for information on care and cleaning of DVDs.

The DVD computer advisory group specifically requested no mandatory caddies or other protective carriers. Consider that laserdiscs, music CDs, and CD-ROMs are likewise subject to scratches, but many video stores and libraries rent them. Major chains such as Blockbuster and West Coast Entertainment rent DVDs in many locations. Most reports of rental disc performance are positive, although if you have problems playing a rental disc, check for scratches.

[1.16] VHS is good enough, why should I care about DVD?

The primary advantages of DVD are video quality, surround sound, and extra features (see [1.2](#)). In addition, DVD will not degrade with age or after many playings like videotape will (which is an advantage for parents with kids who watch Disney videos twice a week!). This is the same thing that makes CDs more collectable than cassette tapes. Did I mention video quality? The better your TV, the bigger the difference in picture quality between VHS and DVD.

If none of this matters to you, then VHS probably is good enough.

[1.17] Is the packaging different from CD?

Manufacturers were worried about customers assuming DVDs would play in their CD player, so they wanted the packaging to be different. Most DVD packages are as wide as a CD jewel box (about 5-5/8") and as tall as a VHS cassette box (about 7-3/8"), as recommended by the Video Software Dealers Association (VSDA). However, no one is being forced to use a larger package size. Some companies use standard jewel cases or paper and vinyl sleeves. Divx discs came in paperboard and plastic Q-Pack cases the same size as a CD jewel case.

Most movies are packaged in the Amaray "keep case," an all-plastic clamshell with clear vinyl pockets for inserts, that's popular among consumers. Time Warner's "snapper," a paperboard case with a plastic lip, is less popular. There's also a "super jewel box," the stretch-limo version of a CD jewel case, that's common in Europe.

[1.18] What's a dual-layer disc? Will it work in all players?

A dual-layer disc has two layers of data, one of them semi-transparent so that the laser can focus through it and read the second layer. Since both layers are read from the same side, a dual-layer disc can hold almost twice as much as a single-layer disc, typically 4 hours of video (see [3.3](#) for more details). Many discs use dual layers. Initially only a few replication plants could make dual-layer discs, but most plants now have the capability. The second layer can use either a PTP (parallel track path) layout where both tracks run in parallel (for independent data or special switching effects), or an OTP (opposite track path) layout where the second track runs in an opposite spiral; that is, the pickup head reads out from the center on the first track then in from the outside on the second track. The OTP layout is designed to provide continuous video across both layers. The layer change can occur anywhere in the video; it doesn't have to be at a chapter point. There's no guarantee that the switch between layers will be seamless. The layer change is invisible on some players, but it can cause the video to freeze for a fraction of a second or as long as 4 seconds on other players. The "seamlessness" depends as much on the way the disc is prepared as on the design of the player. OTP is also called RSDL (reverse-spiral dual layer). The advantage of two layers is that long movies can use higher data rates for better quality than with a single layer. See [1.27](#) for more about layer changes.

There are various ways to recognize dual-layer discs: 1) the gold color, 2) a menu on the disc for selecting the widescreen or fullscreen version, 3) two serial numbers on one side.

The DVD specification requires that players and drives read dual-layer discs. There are very few units that have problems with dual-layer discs--this is a design flaw and should be corrected for free by the manufacturer. Some discs are designed with a "seamless layer change" that technically goes beyond what the DVD spec allows. This causes problems on a few older players.

All players and drives also play double-sided discs if you flip them over. No manufacturer has announced a model that will play both sides, other than a few DVD jukeboxes. The added cost would be hard to justify since discs can hold over 4 hours of video on one side by using two layers. (Early discs used two sides because dual-layer production was not widely supported. This is no longer a problem.) Pioneer LD/DVD players can play both sides of a laserdisc, but not a DVD. (See [2.12](#) for note on reading both sides simultaneously.)

[1.19] Is DVD-Video a worldwide standard? Does it work with NTSC, PAL, and SECAM?

The MPEG video on a DVD is stored in digital format, but it's formatted for one of two mutually incompatible television systems: 525/60 (NTSC) or 625/50 (PAL/SECAM). Therefore, there are two kinds of DVDs: "NTSC DVDs" and "PAL DVDs." Some players only play NTSC discs, others play PAL and NTSC discs. Discs are also coded for different regions of the world (see [1.10](#)). NTSC is the TV format used in Canada, Japan, Mexico, Philippines, Taiwan, United States, and other countries. PAL is the TV format used in most of Europe, most of Africa, China, India, Australia, New Zealand, Israel, North Korea, and other countries. (See the chart at www.remoteviewing.com for a complete list.)

Almost all DVD players sold in PAL countries play both kinds of discs. These *multi-standard* players partially convert NTSC to a 60-Hz PAL (4.43 NTSC) signal. The player uses the PAL 4.43-MHz color subcarrier encoding format but keeps the 525/60 NTSC scanning rate. Most modern PAL TVs can handle this "pseudo-PAL" signal. A few multi-standard PAL players output true 3.58 NTSC from NTSC discs, which requires an NTSC TV or a multi-standard TV. Some players have a switch to choose 60-Hz PAL or true NTSC output when playing NTSC discs. There are a few *standards-converting* PAL players that convert from an NTSC disc to standard PAL output for older PAL TVs. Proper "on the fly" standards conversion requires expensive hardware to handle scaling, temporal conversion, and object motion analysis. Because the quality of conversion in DVD players is poor, using 60-Hz PAL output with a compatible TV provides a better picture than converting from NTSC to PAL. (Sound is not affected by video conversion.)

Most NTSC players can't play PAL discs, and most NTSC TVs don't work with PAL video. A very small number of NTSC players (such as Apex and SMC) can convert PAL to NTSC. External converter boxes are also available, such as the Emerson EVC1595 (\$350). High-quality converters are available from companies such as [TenLab](#) and [Snell and Wilcox](#).

Beware, some standards-converting players can't convert anamorphic widescreen video for 4:3 displays (see [1.22](#)).

The latest software tools such as Adobe *After Effects* and Canopus *ProCoder* do quite a good job of converting between PAL and NTSC at low cost, but they are only appropriate for the production environment (converting the video before it is encoded and put on the DVD). See Snell and Wilcox's [The Engineer's Guide to Standards Conversion](#) and [The Engineer's Guide to Motion Compensation](#) for technical details of conversion.

There are three differences between discs intended for playback on different TV systems: picture dimensions and pixel aspect ratio (720x480 vs. 720x576), display frame rate (29.97 vs. 25), and surround audio options (Dolby Digital vs. MPEG audio). (See [3.4](#) and [3.6](#) for details.) Video from film is usually encoded at 24 frames/sec but is preformatted for one of the two required display rates. Movies formatted for PAL display are usually sped up by 4% at playback, so the audio must be adjusted accordingly before being encoded. All PAL DVD players can play Dolby Digital audio tracks, but not all NTSC players can play MPEG audio tracks. PAL and SECAM share the same scanning format, so discs are the same for both systems. The only difference is that SECAM players output the color signal in the format required by SECAM TVs. Note that modern TVs in most SECAM countries can also read PAL signals, so you can use a player that only has PAL output. The only case in which you need a player with SECAM output is for older SECAM-only TVs (and you'll probably need a SECAM RF connection, see [3.1](#)).

A producer can choose to put 525/60 NTSC video on one side of the disc and 625/50 PAL on the other. Most studios put Dolby Digital audio tracks on their PAL discs instead of MPEG audio tracks.

Because of PAL's higher resolution, the video usually takes more space on the disc than the NTSC version. See [3.4](#) for more details.

There are actually three types of DVD players if you count computers. Most DVD PC software and hardware can play both NTSC and PAL video and both Dolby Digital and MPEG audio. Some PCs can only display the converted video on the computer monitor, but others can output it as a video signal for a TV.

Bottom line: NTSC discs (with Dolby Digital audio) play on over 95% of DVD systems worldwide. PAL discs play on very few players outside of PAL countries. (This is irrespective of regions -- see [1.10](#).)

[1.20] What about animation on DVD? Doesn't it compress poorly?

Some people claim that animation, especially hand-drawn cell animation such as cartoons and anime, does not compress well with MPEG-2 or even ends up larger than the original. Other people claim that animation is simple so it compresses better. Neither is true.

Supposedly the "jitter" between frames caused by differences in the drawings or in their alignment causes problems. An animation expert at Disney pointed out that this doesn't happen with modern animation techniques. And even if it did, the motion estimation feature of MPEG-2 would compensate for it.

Because of the way MPEG-2 breaks a picture into blocks and transforms them into frequency information it can have a problem with the sharp edges common in animation. This loss of high-frequency information can show up as "ringing" or blurry spots along edges (called the Gibbs effect). However, at the data rates commonly used for DVD this problem does not usually occur.

[1.21] Why do some discs require side flipping? Can't DVDs hold four hours per side?

Even though DVD's dual-layer technology (see [3.3](#)) allows over four hours of continuous playback from a single side, some movies are split over two sides of a disc, requiring that the disc be flipped partway through. Most "flipper" discs exist because of producers who are too lazy to optimize the compression or make a dual-layer disc. Better picture quality is a cheap excuse for increasing the data rate; in many cases the video will look better if carefully encoded at a lower bit rate. Lack of dual-layer production capability is also a lame excuse; in 1997 very few DVD plants could make dual-layer discs, but this is no longer the case. Very few players can automatically switch sides, but it's not needed since most movies less than 4 hours long can easily fit on one dual-layer (RSDL) side.

The [Film Vault](#) at DVD Review includes a list of "flipper" discs. Note: A flipper is not the same as a disc with a widescreen version on one side and a pan & scan version or supplements on the other.

[1.22] Why is the picture squished, making things look too skinny?

Answer: RTFM. You are watching an anamorphic picture intended for display only on a widescreen TV. (See [3.5](#) for technical details). You need to go into the player's setup menu and tell it you have a standard 4:3 TV, not a widescreen 16:9 TV. It will then automatically letterbox the picture so you can see the full width at the proper proportions.

In some cases you can change the aspect ratio as the disc is playing (by pressing the "aspect" button on the remote control). On most players you have to stop the disc before you can change aspect. Some discs are labeled with widescreen on one side and standard on the other. In order to watch the fullscreen version you must flip the disc over.

See [1.38](#) for more on letterboxing.

Apparently most players that convert from NTSC to PAL or vice-versa (see [1.19](#)) can't simultaneously letterbox (or pan and scan) an anamorphic picture. Solutions are to use a widescreen TV, a multistandard TV, or an external converter. Or get a better player.

[1.23] Do all videos use Dolby Digital (AC-3)? Do they all have 5.1 channels?

Most DVD-Video discs contain Dolby Digital soundtracks. However, it's not required. Some discs, especially those containing only audio, have PCM tracks. It's possible --but rare-- for a 625/50 (PAL) disc to contain only MPEG audio. Discs with DTS audio are required to also include a Dolby Digital audio track (in a few rare cases they have a PCM track). See [1.32](#) for more on DTS.

Don't assume that the Dolby Digital label is a guarantee of 5.1 channels. A Dolby Digital soundtrack can be mono, dual mono, stereo, Dolby Surround stereo, etc. For example, *Blazing Saddles* and *Caddyshack* have monophonic soundtracks, so the Dolby Digital soundtrack on these DVDs has only one channel. Some DVD packaging has small lettering or icons under the Dolby Digital logo that indicates the channel configuration. In some cases, there is more than one Dolby Digital version of a soundtrack: a 5.1-channel track and a track specially remixed for stereo Dolby Surround. It's perfectly normal for your DVD player to indicate playback of a Dolby Digital audio track while your receiver indicates Dolby Surround. This means the disc contains a two-channel Dolby Surround signal encoded in Dolby Digital format.

See [3.6](#) for more audio details.

[1.24] Can DVDs have "laser rot"?

Before DVDs there were laserdiscs (see [2.6](#)), which were occasionally subject to what was commonly called *laser rot*: the deterioration of the aluminum layer due to oxidation or other chemical change. This usually results from the use of insufficiently pure metal for the reflective coating created during replication, but can be exacerbated by mechanical shear stress due to bending, warping or thermal cycles (the large size of laserdiscs makes them flexible, so that movement along the bond between layers can break the seal -- this is called *delamination*). Deterioration of the data layer can be caused by chemical contaminants or gases in the glue, or by moisture that penetrates the plastic substrate.

Like laserdiscs, DVDs are made of two platters glued together, but DVDs are more rigid and use newer adhesives. DVDs are molded from polycarbonate, which absorbs about ten times less moisture than the slightly hygroscopic acrylic (PMMA) used for laserdiscs.

DVDs can have delamination problems, partly because some cases or players hold too tightly to the hub. Delamination by itself can cause problems (because the data layer is no longer at the correct distance from the surface) and can also lead to oxidation. Delamination may appear as concentric rings or a "stain" around the hub.

So far DVDs have had few "DVD rot" problems. There have been reports of a few discs going bad, possibly due to delamination, contaminated adhesive, chemical reactions, or oxidation of the reflective layer (see mindspring.com/~yerington/ and www.andraste.org/discfault/discfault.htm). The most likely explanation for DVD deterioration is that during the early days of DVD (1997-2000), disc manufacturing processes and materials were not as good as they should have been. Many improvements have been made since then, so the minuscule problem has probably become even more minuscule.

There are also occasional reports of "cloudiness" or "milky" in DVDs, which can be caused by improper replication. An example is when the molten plastic cools off too fast or isn't under enough pressure to completely fill all the bumps in the mold (see this [archived article](#) from [TapeDisc Business](#) for more). Minimal clouding doesn't hurt playback and doesn't seem to deteriorate. If you can see something with your naked eye it is probably not oxidation or other deterioration.

The result of deterioration is that a disc which played perfectly when it was new develops problems later, such as skipping, freezing, or picture breakup. If a disc seems to go bad, make sure it's not dirty, scratched, or warped (see [1.39](#)). Try cleaning it and try playing it in other players. If the disc consistently has problems, it may have deteriorated. If so, there's nothing you can do to fix it, so you should try to get a replacement from the supplier.

[1.25] Which titles are pan & scan only? Why?

Some titles are available only in pan & scan because there was no letterbox or anamorphic transfer made from film. (See [3.5](#) for more info on pan & scan and anamorphic formats.) Since transfers cost \$50,000 to \$100,000, studios may not think a new transfer is justified. In some cases the original film or rights to it are no longer available for a new transfer. In the case of old movies, they were shot full frame in the 1.37 "academy" aspect ratio so no widescreen version can be created. Video shot with TV cameras, such as music concerts, is already in 4:3 format.

There is a list of pan & scan titles in the [Film Vault](#) at DVD Review and in the [Internet Movie Database](#) (which also includes discs with both widescreen and pan & scan versions).

[1.26] How do I make the subtitles on my Pioneer player go away?

On the remote control, press Subtitle, then either Clear or 0 (zero). No need to use the menus.

[1.27] Why does playback sometimes freeze for a second?

Some movies, especially those over two hours long or encoded at a high data rate, are spread across two layers on one side of the disc. When the player changes to the second layer, the video and audio may freeze for a moment. The length of the pause depends on the player and on the layout of the disc. The disc producer usually tries to choose a point where the pause will be less noticeable. The pause is not a defect in the player or the disc. See [1.18](#) for more information.

There is a list of layer switch points in the [Film Vault](#) at DVD Review. Please send new times to info@dvdreview.com.

[1.28] The disc says Dolby Digital. Why do I get 2-channel surround audio?

Some discs (many from Columbia TriStar) have 2-channel Dolby Surround audio (or plain stereo) on track one and 5.1-channel audio on track two. Some studios create separate sound mixes optimized for Dolby Surround or stereo, and they feel the default track should match the majority of sound systems in use. Unless you specifically select the 5.1-channel track (with the audio button on the remote or with the on-screen menu) the player will play the default 2-channel track. (Some players have a feature to automatically select the first 5.1 track.)

Dolby Digital doesn't necessarily mean 5.1 channels. See [1.23](#) and [3.6](#).

[1.29] Why doesn't the repeat A-B feature work on some discs?

Almost all features of DVD such as search, pause, and scan can be disabled by the disc, which can prevent the player from searching back to the beginning of a segment. If the player uses time search to repeat a segment, then a disc with fancy non-sequential title organization will not have timecode information the player needs to search. In many cases the authors don't even realize they have prevented the use of the repeat feature.

[1.30] What's the difference between first, second, and third generation DVD?

There is no meaningful answer to this question, since you'll get a different response from everyone you ask. The terms "2nd generation" and "3rd generation," and so on refer both to DVD-Video players and to DVD-ROM drives. In general, they simply mean newer versions of DVD playback devices. The terms haven't been used (yet) to refer to DVD products that can record, play video games, or so on.

According to some people, second-generation DVD players came out in the fall of 1997 and third-generation players are those that came out in the beginning of 1998. According to others, the second generation of DVD will be HD players (see [2.12](#)) that won't come out until 2003 or so. Many conflicting variations occur between these extremes, including the viewpoint that DTS-compatible players or Divx players or progressive-scan players or 10-bit video players or players that can play *The Matrix* constitute the second, third, or fourth generation.

Things are a little more clear cut on the PC side, where second generation (DVD II) usually means 2x DVD-ROM drives that can read CD-Rs, and third generation (DVD III) usually means 5x (or sometimes 2x or 4.8x or 6x) DVD-ROM drives, a few of which can read DVD-RAMs, and some of which are RPC2 format. Some people refer to RPC2 drives or 10x drives as fourth generation. See section [4.2](#) for more speed info. See section [1.10](#) for an RPC2 explanation.

[1.31] What's a hybrid DVD?

Do you really want the answer to this one? Ok, you asked for it...

1. A disc that works in both DVD-Video players and DVD-ROM PCs. (More accurately called an *enhanced* DVD)
2. A DVD-ROM disc that runs on Windows and Mac OS computers. (More accurately called a *cross-platform* DVD.)
3. A DVD-ROM or DVD-Video disc that also contains Web content for connecting to the Internet. (More accurately called a *WebDVD* or *Enhanced* DVD.)

4. A disc that contains both DVD-Video and DVD-Audio content or SACD content. (More accurately called a *universal* or *AV DVD*. The DVD-Audio standard allows this. The SACD standard does not officially allow video, so it's unclear what a given SACD player will do with a hybrid SACD+DVD-Video disc.) Other variations of this hybrid would be a disc with both DVD-Audio and SACD content, or a disc with all three formats.
5. A disc with two layers, one that can be read in DVD players and one that can be read in CD players. (More accurately called a *legacy* or *CD-compatible* disc.) There are at least three variations of this hybrid, although most aren't commercially available:
 1. A 0.9- to 1.2-mm CD substrate bonded to the back of a 0.6 mm DVD substrate. One side can be read by CD players, the other side by DVD players. The resulting disc is 0.6 mm thicker than a standard CD or DVD, which can cause problems in players with tight tolerances, such as portables. Sonopress, the first company to announce this type, calls it DVDPlus. It's colloquially known as a fat disc. There's a variation in which an 8-cm data area is embedded in a 12-cm substrate so that a label can be printed on the outer ring.
 2. A 0.6-mm CD substrate bonded to a semitransparent 0.6 mm DVD substrate. Both layers are read from the same side, with the CD player being required to read through the semitransparent DVD layer, causing problems with some CD players. The trick is to make the semitransparent layer "invisible" to 780-nm CD lasers. This is the format used for hybrid SACDs.
 3. A 0.6-mm CD substrate, with a special refractive coating that causes a 1.2 mm focal depth, bonded to the back of a 0.6 mm DVD substrate. One side can be read by CD players, the other side by DVD players.
 4. A 0.6-mm DVD substrate bonded to a CD+DVD hybrid substrate (#2 in this subsection). This disc would be readable by SACD and CD players on one side and by standard DVD players on the other (since most standard DVD players are confused by a hybrid disc with only a semitransparent layer).
6. A disc with two layers or two sections one containing pressed (DVD-ROM) data and one containing rewritable (DVD-RAM or other) media for recording. (More accurately called a *DVD-PROM*, *mixed-media*, or *rewritable sandwich* disc.)
7. A disc with two layers on one side and one layer on the other. (More accurately called a *DVD-14*.)
8. A disc with an embedded memory chip for storing custom usage data and access codes. (More accurately called a *chipped* DVD.)
9. A disc that has a foreign language dubbed audio track and also has subtitles in that language.

Did I miss any?

[1.32] What's the deal with DTS and DVD?

Digital Theater Systems Digital Surround is an audio encoding format similar to Dolby Digital. It requires a decoder, either in the player or in an external receiver. See [3.6.2](#) for technical details. Some people claim that, because of its lower compression level, DTS sounds better than Dolby Digital. Others claim there is no meaningfully perceptible difference, especially at the typical data rate of 768 kbps, which is 60% more than Dolby Digital. Because of the many variances in production, mixing, decoding, and reference levels, it's almost impossible to accurately compare the two formats (DTS usually produces a higher volume level, causing it to sound better in casual comparisons).

DTS originally did all encoding in house, but as of October 1999 DTS encoders became available for purchase. DTS titles are often considered to be specialty items intended for audio enthusiasts, so some DTS titles are also available in a Dolby Digital-only version.

DTS is an optional format on DVD. Contrary to uninformed claims, the DVD specification has included an ID code for DTS since 1996 (before the spec was even finalized). Because DTS was slow in releasing encoders and test discs, players made before mid 1998 (and many since) ignore DTS tracks. A few demo discs were created in 1997 by embedding DTS data into a PCM track (the same technique used with CDs and laserdiscs), and these are the only DTS DVD discs that work on all players. New DTS-compatible players arrived in mid 1998, but theatrical DTS discs using the DTS audio stream ID did not appear until January 7, 1999 (they were originally scheduled to arrive in time for Christmas 1997). *Mulan*, a direct-to-

video animation (not the Disney movie) with DTS soundtrack appeared in November 1998. DTS-compatible players carry an official "DTS Digital Out" logo.

Dolby Digital or PCM audio is required on 525/60 (NTSC) discs, and since both PCM and DTS together don't usually leave enough room for quality video encoding of a full-length movie, essentially every disc with a DTS soundtrack also carries a Dolby Digital soundtrack. This means that all DTS discs will work in all DVD players, but a DTS-compatible player and a DTS decoder are required to play the DTS soundtrack. DTS audio CDs work on all DVD players, because the DTS data is encapsulated into standard PCM tracks that are passed untouched to the digital audio output. DTS discs often carry a Dolby Digital 2.0 track in Dolby Surround format instead of a full Dolby Digital 5.1 track.

[1.33] Why is the picture black and white?

You are probably trying to play an NTSC disc in a PAL player, but your PAL TV is not able to handle the signal. If your player has a switch or on-screen setting to select the output format for NTSC discs, choosing PAL (60 Hz) may solve the problem. See section [1.19](#) for more information.

You may have connected one of the component outputs (Y, R-Y, or B-Y) of your DVD player to the composite input of your TV. See section [3.2](#) for hookup details.

[1.34] Why are both sides fullscreen when one side is supposed to be widescreen?

Many DVD's are labeled as having widescreen (16:9) format video on one side and standard (4:3) on the other. If you think both sides are the same, you're probably seeing uncompressed 16:9 on the widescreen side. It may look like 4:3 full-frame, but if you look carefully you'll discover that the picture is horizontally compressed. The problem is that your player has been set for a widescreen TV. See [1.22](#) for details.

[1.35] Why are the audio and video out of sync?

There have been numerous reports of "lip sync" problems, where the audio lags slightly behind the video or sometimes precedes the video. Perception of a sync problem is highly subjective; some people are bothered by it while others can't discern it. Problems have been reported on a variety of players (notably the Pioneer 414 and 717 models, possibly all Pioneer models, some Sony models including the 500 series and the PS2, some Toshiba models including the 3109, and some PC decoder cards). Certain discs are also more problematic (notably *Lock, Stock, and Two Smoking Barrels*; *Lost In Space*; *TRON*; *The Parent Trap*; and *Austin Powers*).

The cause of the sync problem is a complex interaction of as many as four factors

1. Improper sync in audio/video encoding or DVD-Video formatting.
2. Poor sync during film production or editing (especially post-dubbing or looping).
3. Loose sync tolerances in the player.
4. Delay in the external decoder/receiver.

Factor 1 or 2 usually must be present in order for factor 3 or 4 to become apparent. Some discs with severe sync problems have been reissued after being re-encoded to fix the problem. In some cases, the sync problem in players can be fixed by pausing or stopping playback and then restarting, or by turning the player off, waiting a few seconds, then turning it back on.

A good way to test your player is to simultaneously listen to the analog and digital outputs (play the digital output through your stereo and the analog output through your TV). If the audio echoes or sounds hollow, then the player is delaying the signal and is thus the main cause of the sync problem.

Unfortunately, there is no simple answer and no simple fix. More complaints from customers should motivate manufacturers to take the problem more seriously and correct it in future players or with firmware upgrades. Pioneer originally stated that altering the audio-visual synchronization of their players "to compensate for the software quality would dramatically compromise the picture performance." Since then Pioneer has fixed the problem on its new players. If you have an older model, check with Pioneer about an upgrade.

For many more details, see Michael D's [Pioneer Audio Sync](#) page.

[1.36] Why does the picture alternate between light and dark?

You are seeing the effects of Macrovision copy protection (see [1.11](#)), probably because you are running your DVD player through your VCR or VCR/TV combo (see [3.2.1](#)).

[1.37] How do I find "Easter eggs" and other hidden features?

Some DVD movies contain hidden features, often called Easter eggs. These are extra screens or video clips hidden in the disc by the developers. For example, *Dark City* includes scenes from *Lost in Space* and the *Twin Peaks* movie buried in the biography pages of William Hurt and Kiefer Sutherland. There's also an amusing "Shell Beach" game entwined throughout the menus. On *Mallrats*, perhaps indicating that DVD has already become too postmodern for its own good, there's a hidden clip of the director telling you to stop looking for Easter eggs and do something useful.

It's more fun to search for hidden features on your own, but if you need some help, the best list is at [DVD Review](#).

[1.38] How do I get rid of the black bars at the top and bottom?

The black bars are part of the *letterbox* process (see [3.5](#)), and in many cases you can't get rid of them. If you set the display option in your player to pan & scan (sometimes called fullscreen or 4:3) instead of letterbox, it won't do you much good since almost no DVD movies have been released with this feature enabled. If you set the player to 16:9 widescreen output it will make the bars smaller, but you will get a tall, stretched picture on a standard TV.

In some cases, there may be both a fullscreen and a letterbox version of the movie on the same disc, with a variety of ways to get to the fullscreen version (usually only one works, so you may have to try all three):

1. Check the other side of the disc (if it's two-sided)
2. Look for a fullscreen choice in the main menu
3. Use the "aspect" button on the remote control

DVD was designed to make movies look as good as possible on TV. Since most movies are wider than most TVs, letterboxing preserves the format of the theatrical presentation. (Nobody seems to complain that the top and bottom of the picture are cut off in theaters.) DVD is ready for TVs of the future, which are widescreen. For these and other reasons, many movies on DVD are only available in widescreen format.

About two thirds of widescreen movies are filmed at 1.85 (flat) aspect ratio or less. In this case, the actual size of the image on your TV is the same for a letterbox version and a full-screen version, unless the pan & scan technique is used to zoom in (which cuts off part of the picture). In other words, the picture is **the same size**, with extra areas visible at the top and bottom in the fullscreen version. In more other words, letterboxing covers over the part of the picture that was also covered in the theater, or it allows the entire widescreen picture to be visible for movies wider than 1.85, in which case the letterboxed picture is smaller and has less detail than a pan & scan version would.

If there's not a fullscreen version of the movie on the disc, one solution is to use a DVD player with a zoom feature to enlarge the picture enough to fill the screen. This will cut off the sides of the picture, but in many cases it's a similar effect to the pan and scan process. Just think of it as "do-it-yourself pan and scan."

For a detailed explanation of why most movie fans prefer letterboxing, see the [Letterbox/Widescreen Advocacy Page](#). For an explanation of anamorphic widescreen and links to more information and examples on other Web sites, see [3.5](#).

The best solution to this entire mess might be the [FlikFX Digital Recomposition System](#), "the greatest advance in entertainment in 57 years."

[1.39] How should I clean and care for DVDs?

Since DVDs are read by a laser, they are resistant to fingerprints, dust, smudges, and scratches (see [1.15](#) for more info). However, surface contaminants and scratches can cause data errors. On a video player,

the effect of data errors ranges from minor video artifacts to frame skipping to complete unplayability. So it's a good idea to take care of your discs. In general treat them the same way as you would a CD.

Your player can't be harmed by a scratched or dirty disc unless globs of nasty substances on it actually hit the lens. Still, it's best to keep your discs clean, which will also keep the inside of your player clean. Don't attempt to play a cracked disc, as it could shatter and damage the player. It doesn't hurt to leave the disc in the player, even if it's paused and still spinning, but leaving it running unattended for days on end might not be a good idea.

In general, there's no need to clean the lens on your player, since the air moved by the rotating disc keeps it clean. However, if you use a lens cleaning disc in your CD player, you may want to do the same with your DVD player. It's advisable to use a cleaning disc specifically designed for DVD players, because there are minor differences in lens positioning between DVD and CD players.

Periodic alignment of the pickup head is not necessary. Sometimes the laser can drift out of alignment, especially after rough handling of the player, but this is not a regular maintenance item.

Care and feeding of DVDs

Handle only at the hub or outer edge. Don't touch the shiny surface with your popcorn-greasy fingers.

Store in a protective case when not in use. Don't bend the disc when taking it out of the case, and be careful not to scratch the disc when placing it in the case or in the player tray.

Make certain the disc is properly seated in the player tray before you close it.

Keep discs away from radiators, heaters, hot equipment surfaces, direct sunlight (near a window or in a car during hot weather), pets, small children, and other destructive forces. The DVD specification recommends that discs be stored at a temperature between -20 to 50 °C (-4 to 122 °F) with less than 15 °C (27 °F) variation per hour, at relative humidity of 5 to 90 percent. Artificial light and indirect sunlight have no effect on replicated DVDs since they are made of polycarbonate, polymer adhesives, and metal (usually aluminum or gold), none of which are significantly affected by exposure to light. Exposure to bright sunlight may affect recordable DVDs, specifically write-once DVDs (DVD-R and DVD+R) that use light-sensitive dyes. Magnetic fields have no effect on DVDs, so it's ok to leave them sitting on your speakers.

Coloring the outside edge of a DVD with a green marker (or any other color) makes no difference in video or audio quality. Data is read based on pit interference at 1/4 of the laser wavelength, a distance of less than 165 nanometers. A bit of dye that on average is more than 3 million times farther away is not going to affect anything.

NIST has prepared a [1-page guide](#) and a [50-page guide](#) to disc care.

Cleaning and repairing DVDs

If you notice problems when playing a disc, you may be able to correct them with a simple cleaning.

- Do not use strong cleaners, abrasives, solvents, or acids.
- With a soft, lint-free cloth, wipe gently in only a radial direction (a straight line between the hub and the rim). Since the data is arranged circularly on the disc, the micro scratches you create when cleaning the disc (or the nasty gouge you make with the dirt you didn't see on your cleaning cloth) will cross more error correction blocks and be less likely to cause unrecoverable errors.
- Don't use canned or compressed air, which can be very cold and may thermally stress the disc.
- For stubborn dirt or gummy adhesive, use water, water with mild soap, or isopropyl alcohol. As a last resort, try peanut oil. Let it sit for about a minute before wiping it off.
- There are commercial products that clean discs and provide some protection from dust, fingerprints, and scratches. CD cleaning products work as well as DVD cleaning products.

If you continue to have problems after cleaning the disc, you may need to attempt to repair one or more scratches. Sometimes even hairline scratches can cause errors if they just happen to cover an entire error correction (ECC) block. Examine the disc to find scratches, keeping in mind that the laser reads from the bottom. There are essentially two methods of repairing scratches: 1) fill or coat the scratch with an optical

material; 2) polish down the scratch. There are many commercial products that do one or both of these, or you may wish to do it yourself with polishing compounds or toothpaste. The trick is to polish out the scratch without causing new ones. A mess of small polishing scratches may cause more damage than a big scratch. As with cleaning, polish only in the radial direction.

Libraries, rental shops, and other venues that need to clean a lot of discs may want to invest in a commercial polishing machine that can restore a disc to pristine condition after an amazing amount of abuse. Keep in mind that the data layer on a DVD is only half as deep as on a CD, so a DVD can only be repolished about half as many times.

[1.40] What's a progressive DVD player?

A progressive-scan DVD player converts the interlaced (480i) video from DVD into progressive (480p) format for connection to a progressive-scan display (31.5 kHz or higher). Progressive players work with all standard DVD titles, but look best with film source. The result is a significant increase in perceived vertical resolution for a more detailed and film-like picture. Since computers use progressive-scan monitors, DVD PCs are by definition progressive-scan players, although quality varies quite a bit (see [4.1](#) and [2.12](#)).

There's enormous confusion about whether DVD video is progressive or interlaced. Here's the one true answer: Progressive-source video (such as from film) is usually encoded on DVD as interlaced field pairs that can be reinterleaved by a progressive player to recreate the original progressive video. See [3.8](#) for further explanation of interlaced and progressive scanning.

You must use a progressive-scan display in order to get the full benefit of a progressive-scan player. However, all progressive players also include interlaced outputs, so you can use one with a standard TV until you upgrade to a progressive TV. (You may have to use a switch on the back of the player to set it to interlaced output.)

Toshiba developed the first progressive-scan player (SD5109, \$800) in mid 1998, but didn't release it until fall of 1999 because of copy protection concerns. Panasonic also released a progressive-scan player (DVD-H1000, \$3000) in fall of 1999. Many manufacturers have released progressive models since then at progressively cheaper prices (pun intended). It's also possible to buy an external *line multiplier* to convert the output of a standard DVD player to progressive scanning.

Converting interlaced DVD video to progressive video involves much more than putting film frames back together. There are essentially three ways to convert from interlaced to progressive:

- 1- *reinterleaving* (also called *weave*). If the original video is from a progressive source, such as film, the two fields can be recombined into a single frame.
- 2- *Line doubling* (also called *bob*). If the original video is from an interlaced source, simply combining two fields will cause motion artifacts (the effect is reminiscent of a zipper), so each line of a single field is repeated twice to form a frame. Better line doublers use *interpolation* to produce new lines that are a combination of the lines above and below. The term line doubler is vague, since cheap line doublers only bob, while expensive line doublers (those that contain digital signal processors) can also weave.
- 3- *Field-adaptive* deinterlacing, which examines individual pixels across three or more fields and selectively weaves or bobs regions of the picture as appropriate. Chips to do this used to cost \$10,000 and up, but the feature is now appearing in consumer DVD players.
- 4- And there's also a fourth way, called *motion-adaptive* deinterlacing, which examines MPEG-2 motion vectors or does massive image processing to identify moving objects in order to selectively weave or bob regions of the picture as appropriate. Most systems that do this well cost \$50,000 and up (aside from the cool but defunct Chromatic Mpack2 chip).

There are three common kinds of deinterlacing systems:

- 1- *Integrated*. This is usually best, where the deinterlacer is integrated with the MPEG-2 decoder so that it can read MPEG-2 flags and analyze the encoded video to determine when to bob and when to weave. Most DVD computers use this method.
- 2- *Internal*. The digital video from the MPEG-2 decoder is passed to a separate deinterlacing chip. The disadvantage is that MPEG-2 flags and motion vectors may no longer be available to help the deinterlacer determine the original format and cadence. (Some internal chips receive the `repeat_first_field` and `top_field_first` flags passed from the decoder, but not the `progressive_scan` flag.)
- 3- *External*. Analog video from the DVD player is passed to a separate deinterlacer (line multiplier) or to a display with a built-in deinterlacer. In this case, the video quality is slightly degraded from being converted to analog, back to digital, and often back again to analog. However, for high-end projection systems, a separate line multiplier (which scales the video and interpolates to a variety of scanning rates) may achieve the best results.

Most progressive DVD players use an internal deinterlacing chip, usually from Genesis/Faroudja. Some use MPEG decoders with integrated deinterlacing. Some, such as Toshiba's "Super Digital Progressive" players and Panasonic's progressive-scan player add 4:4:4 chroma oversampling, which provides a slight quality boost from DVD's native 4:2:0 format. Add-on internal deinterlacers such as the Cinematrix and [MSB Progressive Plus](#) are available to convert existing players to progressive-scan output. [Faroudja](#), [Silicon Image](#) (DVDO), and [Videon](#) (Omega) line multipliers are examples of external deinterlacers.

A progressive DVD player has to determine whether the video should be line-doubled (*bobbed*) or reinterleaved (*weaved*). When reinterleaving film-source video, the player also has to deal with the difference between film frame rate (24 Hz) and TV frame rate (30 Hz). Since the 2-3 pulldown trick can't be used to spread film frames across video fields, there are worse motion artifacts than with interleaved video. However, the increase in resolvable detail more than makes up for it. Advanced progressive players such as the Princeton PVD-5000 and DVD computers can get around the problem by displaying at multiples of 24 Hz such as 72 Hz, 96 Hz, and so on.

A progressive player also has to deal with problems such as video that doesn't have clean cadence (as when it's edited after being converted to interlaced video, when bad fields are removed during encoding, when the video is speed-shifted to match the audio track, and so on). Another problem is that many DVDs are encoded with incorrect MPEG-2 flags, so the reinterleaver has to recognize and deal with pathological cases. In some instances it's practically impossible to determine if a sequence is 30-frame interlaced video or 30-frame progressive video. For example, the documentary on *Apollo 13* is interlaced video encoded as if it were progressive. Other examples of improper encoding are *Titanic*, *Austin Powers*, *Fargo*, *More Tales of the City*, the *Galaxy Quest* theatrical trailer, and *The Big Lebowski* making-of featurette.

One problem is that many TVs with progressive input don't allow the aspect ratio to be changed -- they assume all progressive-scan input is anamorphic. When a non-anamorphic (4:3) picture is sent to these TVs they distort it by stretching it out! Before you buy a DTV, make sure that it allows aspect ratio adjustment on progressive input. Or get a player with an *aspect ratio control* option that "windowboxes" 4:3 video into a 16:9 rectangle by squeezing it horizontally and adding black bars on the side. Because of the added scaling step this degrades picture quality, but at least it gets around the problem.

Just as early DVD computers did a poor job of progressive-scan display of DVDs, the first generations of progressive consumer players are also a bit disappointing. But as techniques improve, and as DVD producers become more aware of the steps they must take to ensure good progressive display, and as more progressive displays appear in homes, the experience will undoubtedly improve, bringing home theaters closer to real theaters.

For more on progressive video and DVD, see [part 5](#) and [player ratings](#) in the excellent [DVD Benchmark](#) series at Secrets of Home Theater and High Fidelity.

[1.41] Why doesn't disc X work in player Y?

The DVD specification is complex and open to interpretation. DVD-Video title authoring is also very complex. As with any new technology, there are compatibility problems. The DVD-Video standard has not changed substantially since it was finalized in 1996, but many players don't properly support it. Discs have become more complex as authoring tools improve, so recent discs often uncover engineering flaws in players. Some discs behave strangely or won't play at all in certain players. In some cases, manufacturers can fix the problem with an upgrade to the player (see [1.47](#)). In other cases, disc producers need to reauthor the title to correct an authoring problem or to work around a player defect. Problems can also occur because of damaged or defective discs or because of a defective player.

If you have problems playing a disc, try the following:

1. Check the list below to see if it's a reported problem. Also check the list of problem discs in DVD Review's [Film Vault](#) and at [InterActual's tech support page](#). Try a newsgroup search at [Google](#).
2. Try playing the disc a few more times. If you don't get the exact same problem every time, then it's probably a defective or damaged disc. Make sure the disc isn't dirty or scratched (see [1.39](#)).
3. Try the disc in a different player. (Visit a friend or a nearby store that sells players.) If the disc plays properly in a different player then your player is likely at fault. Contact the manufacturer of your player for a firmware upgrade. Or, if you bought the player recently, you may wish to return it for a different model.

4. Try a different copy of the disc. If the problem doesn't recur, it indicates that your first copy was probably damaged or defective. If more than one copy of the disc has problems in more than one player, it may be a misauthored disc. Contact the distributor or the studio about getting a corrected disc.
5. If it's a recordable disc (R/RW), your player might not be able to read it (see [4.3.1](#)).

For other DVD and home theater problems, try [Doc DVD](#) or DVD Digest's [Tech Support Zone](#). If you have a Samsung 709, see the [Samsung 709 FAQ](#). For troubleshooting DVD on computers, see [4.6](#). The [Dell Inspiron 7000 DVD Movie List](#) has Inspiron-specific problems.

Below are problems reported by readers of this FAQ. The FAQ author has not verified these claims and takes no responsibility for their accuracy. Please [report](#) other confirmed problems.

Title	Player	Problem	Solution
various Polygram titles	early Toshiba and Magnavox models	won't load or freezes	upgrade available from Toshiba service centers
various Central Park Media (anime) titles	<i>similar problems as The Matrix</i>		
any all-region title	many JVC models	rejects disc	
RCE titles (see 1.10)	Fisher DVDS-1000, Sanyo Model DVD5100	world map and "only plays on non-modified players" message	contact tech Sanyo/Fisher support for workaround
The Abyss, SE	early Toshiba models	disc 2 won't load or freezes	upgrade available from Toshiba service centers
	many cheap players	repeats scenes	player doesn't properly handle seamless branching, get upgrade from manufacturer
	Apex AD-600A	scenes play twice	check with Apex for upgrade
AI (PAL region 2)	Wharfdale 750	won't play	
Akira SE	Pioneer DV-37, DV-737, DV-525	freezes in several places	fast forward to skip trouble spots
Aliens 20th Anniversary Edition	Pioneer DV-S737	picture degrades after layer change	
American Beauty (Awards Edition)	Toshiba SD-3108, Philips DVD805	won't load	upgrade from manufacturer service center (Toshiba firmware 3.30 or newer)
American Pie	Philips 940	freezes at layer change (1:17:09)	
Any Given Sunday	Pioneer Elite DVL90	won't load	upgrade from Pioneer service center

Arlington Road	<i>see Cruel Intentions</i>		
Armageddon	Panasonic A115-U and A120-U	won't load	unplug player with disc inserted, plug in, turn on
Avenger's TV series (A&E)	Toshiba SD-3108	locks up player	upgrade available from Toshiba service centers
	Philips 930, 935	won't load	check with Philips for firmware upgrade
Back to the Future Trilogy (region 4)	various players	"anecdote" subpictures don't play properly	
Bats	Apex AD 600A	won't load	check with Apex for upgrade
Big Trouble in Little China Special Edition	Panasonic SC-DK3	won't load	unplug player with disc inserted, plug in, turn on
The Blair Witch Project	some Toshiba players	doesn't play properly	upgrade available from Toshiba service centers
Bruce Springsteen: Live in Barcelona	various players	menu doesn't work or tour documentary doesn't play	call Sony Pictures at 800-255-7514 for a new version of the disc
Cheers, Season 2	Apex AD-3201	no audio	
Cruel Intentions	some JVC and Yamaha players	error in first release messes up parental controls, causing other discs to not play	reset the player or get the corrected version of the disc or set parental country code to AD with password of 8888
Deep Blue Sea	<i>similar problems as The Matrix</i>		
Dinosaur	many players (JVC-XV501BK, Philips DVD781 CH, Pioneer DV-737/ DV-37/ DV-09/ DVL-919/ DV-525/ DVL-90/ KV-301C, Sony 7700, Panasonic A300, Toshiba SD-3109, RCA 5220, Denon DVD 2500, Magnavox DVD502AT Toshiba 2109/3109, JVC XV-D2000/XV-D701 Oritron DVD600/DVD100, Sylvania DVL100A, and others)	won't load, ejects disc, freezes, skips, slow menus, won't pause/forward/rewind, sound cuts out	authoring problem -- contact Disney for a replacement (also see Disney's The Kid below)
Disney's The Kid	many players (Apex 600AD, Philips 711, Pioneer DV-737, RCA, and others)	skips, ejects disc, freezes, blue lines on screen	authoring problem -- contact Disney for a replacement; (solution on Philips player: put disc in drawer, do not close drawer, press "1" on remote to jump to chapter 1)

Dragon's Lair	Toshiba SD-2109/3109 (before mid 1999)	various	upgrade available from Toshiba service centers
	most Samsung, Aiwa	various	check with Samsung (800-726-7864) or Aiwa for firmware upgrade
Enigma-2002	Toshiba SD-4700	won't play	
Entrapment	JVC, Sony 850	freezes	check with JVC for firmware upgrade
	Sigma Hollywood Plus	see <i>The World Is Not Enough</i>	
Everything, Everything (Underworld)	Toshiba SD3108 and SD3109	won't load	upgrade available from Toshiba service centers
Evolution	Many computer DVD software players	won't play	contact studio for new version of disc
Finding Nemo	Pioneer DV-563AS	pixelization in spots (especially Sea Turtle sequence)	
Galaxy Quest	most Samsung players	freezes at chapter 7	check with Samsung (800-726-7864) for firmware upgrade
Girl, Interrupted	Apex AD-600A, Shinco 2120, Smart DVDMP3000, others	jumps to Features menu, won't play movie	press Resume on remote control; upgrade available for Smart
Gladiator	Toshiba SD3108/SD3109, Wharfedale DVD 750, others	won't load	contact studio for new version of disc
The Godfather Collection, bonus disc	A few players	various problems	upgrade your player or get new disc from Paramount (replacement disc works around player bugs)
Good Will Hunting	Apex AD-3201	won't play audio commentary	
Idle Hands	see <i>Cruel Intentions</i>		
In the Heat of the Night	Pioneer Elite DVL-90	won't play	
In Too Deep	Toshiba SD-5109	won't play Dolby Digital audio unless PCM (music video) played first	
Independence Day	Toshiba SD3108 and SD3109	won't load	upgrade available from Toshiba service centers
	Philips DVD805 and DVD855	won't load	check for upgrade from Philips
	many cheap players	repeats scenes	player doesn't properly handle seamless branching, get

			upgrade from manufacturer
Insomnia	Toshiba SD1700	stutters and freezes	
The Last Broadcast	GE 1105P	won't load	
The Last Of the Mohicans	<i>see The World Is Not Enough</i>		
The Lord of the Rings: The Two Towers, Extended Edition	Aiwa XD-DV370	discs 3 and 4 won't play	check with Aiwa
Lord Peter Wimsey: The Nine Taylors	Yamaha DVD-C900	disc 2 won't load or freezes in menu	
Lost In Space	Sharp	freezes	
	Creative DXR3	freezes, audio out of sync	check for updated drivers
The Man With The Golden Gun	a few first-generation players, many software player	garbled video after layer change	might be a disc authoring error
The Matrix	various players	various problems	details at InterActual tech support (for GE 1105-P, serial number beginning with 940 or lower, get upgrade from GE; see Samsung 709 FAQ)
Mission Impossible II	Toshiba SD-3108	won't load	get upgrade from manufacturer service center
Mission to Mars	Toshiba SD-3108	won't load	get upgrade from manufacturer service center
Monsters Inc.	Various players	locks up near end of movie	seems to be player flaws -- check for player upgrade; Disney may re-author disc with a workaround
The Mummy	Philips 930, 935	won't load	
The Mummy Returns	Zenith DVD 2200	Video skewed left or right on bonus material	
The Patriot	Apex AD 600A	wont' play movie	check with Apex for upgrade (pressing Resume may work)
	JVC XV-511BK	won't load	check with JVC for upgrade
The Perfect Storm	Toshiba SD-3108	won't load	get upgrade from manufacturer service center
Planet of the Apes	Toshiba SD-2109	PIP feature activates and locks up when the two ape generals fight.	

The Princess Bride Special Edition	Toshiba SD-3109	freezes during first sword fight scene	
Saving Private Ryan	all players	distortion (smearing, flares) in beach scene at end of ch. 4	This is a deliberate camera effect in the film. Stop returning discs.
Scary Movie	Creative Encore 12x, GE 1105P	crashes in FBI warning	try to skip past FBI warning; check for bug fix from Creative
The Simpsons; The Complete Second Season	Yamaha DVD-C900	some special features on disc 4 cause player to crash	
The Sixth Sense	Sigma Hollywood Plus	MMSYSTEM275 error	wait for a software update from Sigma
Sleepy Hollow	some Toshiba players	doesn't play properly	upgrade available from Toshiba service centers
Snow White	Windows 2000 and Windows XP	doesn't play movie	fix available from Microsoft
Space Ace	<i>see Dragon's Lair</i>		
Stargate SE	Magnavox 400AT	freezes in director's commentary	
Stuart Little	<i>see Girl Interrupted</i>		
The Three Kings	LG DVD-2310P	won't play extras	
Thomas the Tank Engine	<i>see Girl Interrupted</i>		
Tomorrow Never Dies	Sharp 600U Bush DVD2000	locks up player won't load	
Universal Soldier	Wharfedale 750	picture breakup after ch. 30	might be a problem with the disc
Wild Wild West	Samsung DVD 709; Philips 930, 935; GE 1105P	won't load	check with Samsung (800-726-7864), Philips, or GE for firmware upgrade
The World Is Not Enough	Sigma Hollywood Plus	MMSYSTEM275 error	Wait for a software update from Sigma. Might be related to trying to play in wrong region.
The World Is Not Enough (region 2)	Philips 750	stutters and freezes	presumably a flaw in the player; plays region 1 version ok
You've Got Mail	various players	various problems	details at InterActual tech support

[1.42] How do the parental control and multi-rating features work?

DVD includes parental management features for blocking playback and for providing multiple versions of a movie on a single disc. Players (including software players on PCs) can be set to a specific parental level using the onscreen settings. If a disc with a rating above that level is put in the player, it won't play. In some cases, different programs on the disc have different ratings. The level setting can be protected with a password.

A disc can also be designed so that it plays a different version of the movie depending on the parental level that has been set in the player. By taking advantage of the seamless branching feature of DVD, objectionable scenes are automatically skipped over or replaced during playback. This requires that the disc be carefully authored with alternate scenes and branch points that don't cause interruptions or discontinuities in the soundtrack. There is no standard way to identify which discs have multi-rated content.

Unfortunately, very few multi-rating discs have been produced. Hollywood studios are not convinced that there is a big enough demand to justify the extra work involved (shooting extra footage, recording extra audio, editing new sequences, creating branch points, synchronizing the soundtrack across jumps, submitting new versions for MPAA rating, dealing with players that don't properly implement parental branching, having video store chains refuse to carry discs with unrated content, and much more). If this feature is important to you, let the studios know. A list of studio addresses is available at [DVD File](#), and there's a Studio and Manufacturer Feedback area at [Home Theater Forum](#). You might also want to visit the [Viewer Freedom](#) site.

Multi-ratings discs include *Kalifornia*, *Crash*, *Damage*, *Embrace of the Vampire*, *Poison Ivy*, *Species II*. In most cases these discs provide "un-cut" or unrated versions that are more intense than the original theatrical release. Discs that use multi-story branching (not always seamless) for a director's cut or special edition version include *Dark Star*, *Stargate SE*, *The Abyss*, *Independence Day*, and *Terminator 2 SE* (2000 release). Also see multipath movies at [Brilliant Digital](#).

Another option is to use a software player on a computer that can read a playlist telling it where to skip scenes or mute the audio. Playlists can be created for the thousands of DVD movies that have been produced without parental control features. [ClearPlay](#) seems to be the most successful product of this type. A shareware Cine-bit DVD Player did this, but it has been withdrawn apparently because of legal threats from [Nissim](#), who seem determined to stifle the very market they claim to support. A Canadian company, [Select Viewing](#), is releasing software for customized DVD playback on Windows PCs. A few similar projects are under development.

Yet another option is [TVGuardian](#), a device that attaches between the DVD player and the TV to filter out profanity and vulgar language. The box reads the closed caption text and automatically mutes the audio and provides substitute captions for objectionable words. (Note that current versions of these devices don't work with digital audio connections, and don't work with DVDs without NTSC Closed Captioning.)

[1.43] Which discs include multiple camera angles?

There's a euphemism in the DVD industry, where "multi-angle titles" --spoken with the right inflection-- means adult titles. However, apart from thousands of XXX-rated discs, not very many mainstream DVDs have multiple angles, since it takes extra work and limits playing time (a segment with two angles uses up twice as much space on the disc).

Short Cinema Journal vol. 1 was one of the first to use camera angles, in the animated "Big Story," which is also available on the DVD Demystified first edition [sample disc](#). *Ultimate DVD* (Gold or Platinum) is another sample disc with examples of angles. [King Crimson: Deja Vroom](#) has excellent angles, allowing you to focus on any of the musicians. Other multi-angle music discs include *Dave Matthews Band: Listener Supported*, *Metallica Cunning Stunts*, *Sarah McLachlan Mirrorball*. Some movies, such as *Detroit Rock City* (KISS video), *Ghostbusters SE*, *Mallrats*, *Suicide Kings*, *Terminator 2 SE*, and *Tomorrow Never Dies SE* use multiple angles in supplements. Some discs, especially those from Buena Vista, use the angle feature to show credits in the selected language (usually with the angle key locked out).

You can get an incomplete list of multi-angle discs by doing an [extended search](#) at DVD File or other sites with searchable databases (see [1.6](#)).

[1.44] Is it ok to put labels or magnetic strips on DVDs?

Labels and adhesive strips are dangerous because they can unbalance the disc and cause errors, or even damage a player, especially if they peel off while the disc is spinning. Pressure-sensitive adhesives break down over time, so it's possible for labels to come loose after a few years. Libraries and DVD rental outlets often want to label discs or attach magnetic strips for security, but it's best not to use them at all. If you must, use a ring-shaped "donut" label that goes around the center of the disc. As long as the circular label doesn't interfere with the player clamping onto the hub, it should be ok. If you have to use a non-circular sticker, place it as close to the center as possible to minimize unbalancing. Placing a second sticker straight across from the center will also help. Writing with a marker in the clear (not reflective) area at the hub is better than using a sticker, although there's not much room to write. Write only in the

area inside a 44-mm diameter. Writing anywhere else on the disc is risky, since the ink could possibly eat away the protective coating and damage the data layer underneath.

In most cases a better alternative for security is a case that can only be opened with special equipment at the register or checkout counter. Barcodes, stickers, and security strips can be placed on the case without endangering discs (or players). This is especially good for double-sided discs, which have no space for stickers.

There are full-size round labels designed to go on recordable CDs and DVDs, but they have been known to cause problems. As DVD-ROM drives get faster and faster, destabilization of the disc by a label may cause read errors. A better (but more expensive) solution is to use an inkjet disc printer ([IMT](#), [Odixion](#), [Primera](#), [Rimage](#), [Trace Affex](#)) with printable-surface discs.

[1.45] What's the difference between Closed Captions and subtitles?

Closed Captions (CC) are a standardized method of encoding text into an NTSC television signal. The text can be displayed by a TV with a built-in decoder or by a separate decoder. All TVs larger than 13 inches sold in the US since 1993 have Closed Caption decoders. Closed Captions can be carried on DVD, videotape, broadcast TV, cable TV, and so on.

Even though the terms *caption* and *subtitle* have similar definitions, *captions* commonly refer to on-screen text specifically designed for hearing impaired viewers, while *subtitles* are straight transcriptions or translations of the dialogue. Captions are usually positioned below the person who is speaking, and they include descriptions of sounds (such as gunshots or closing doors) and music. *Closed* captions are not visible until the viewer activates them. *Open* captions are always visible, such as subtitles on foreign videotapes.

Closed Captions on DVDs are carried in a special data channel of the MPEG-2 video stream and are automatically sent to the TV. You can't turn them on or off from the DVD player. Subtitles, on the other hand, are DVD subpictures, which are full-screen graphical overlays (see [3.4](#) for technical details). One of up to 32 subpicture tracks can be turned on to show text or graphics on top of the video. Subpictures can also be used to create captions. To differentiate from NTSC Closed Captions and from subtitles, captions created as subpictures are usually called "captions for the hearing impaired."

If this is all too confusing, just follow this advice: To see Closed Captions, use the CC button on the TV remote. To see subtitles or captions for the hearing impaired, use the subtitle button on the DVD remote or use the onscreen menu provided by the disc. Don't turn both on at once or they'll end up on top of each other. Keep in mind that not all DVDs have Closed Captions or subtitles. Also, some DVD players don't reproduce Closed Captions at all.

See DVD File's [A Guide to DVD Subtitles and Captioning](#), Gary Robson's [Caption FAQ](#), and Joe Clark's [DVD Accessibility](#) for more about Closed Captions. Note that DVD does not support PAL Teletext, the much-improved European equivalent of Closed Captions.

[1.46] What do the "D" codes on region 2 DVDs mean?

Some non-U.S. discs from Warner, MGM, and Disney are marked with a distribution zone number. "D1" identifies a UK-only release. These often have English-only soundtracks with BBFC censoring. "D2" and "D3" identify European DVDs that are not sold in the UK and Ireland. These often contain uncut or less cut versions of films. "D4" identifies DVDs that are distributed throughout all of Europe (region 2) and Australia/New Zealand (region 4).

[1.47] What's firmware and why would I need to upgrade it?

DVD players are simple computers. Each one has a software program that controls how it plays discs. Since the software is stored on a chip, it's called firmware. Some players have flaws in their programming that cause problems playing certain DVDs. In order to correct the flaws, or in some cases to work around authoring errors on popular discs, the player must be upgraded with a replacement firmware chip. This usually has to be done in a factory service center, although some players can be upgraded simply by inserting a CD. See [1.41](#) for more on compatibility problems.

[1.48] Are there discs to help me test, optimize, or show off my audio/video system?

A few DVDs are designed specifically for testing and optimizing video and audio playback. Some also demonstrate special features of DVD:

- AVIA Guide to Home Theater, [Ovation Software](#) (extensive video and audio test patterns and setup tutorials)
- Video Essentials, [Joe Kane Productions](#) (the original system optimization disc, from the master)
- Ultimate DVD series, [Henninger Interactive](#) (examples of many DVD features, plus test and demo material)
- [DVD Demystified demo disc](#) (examples of almost every DVD feature, plus demo material)

Here are a few movies that work especially well for demonstrating DVD's video and audio quality:

- *Dinosaur* - Direct-to-DVD digital transfer gives sharp, clear images; good bass on footsteps and fights.
- *The Eagles: Hell Freezes Over* - Outstanding 5.1-channel music (DTS only, Dolby Digital tracks are 2-channel).
- *The Fifth Element* - Excellent video, especially in beginning desert scenes, with stellar audio as well.
- *Gladiator* - Stunning surround audio with brilliantly mixed orchestration.
- *O Brother, Where Art Thou* - Beautiful color and incredible detail (check out facial stubble) with well-rendered shadows.
- *Terminator 2: Judgment Day (Ultimate Edition)* - Great video for shadows and reds; highly dimensional audio.
- *Toy Story 2* - Perfect all-digital transfer results in sharp, rich images; sound effects are nicely staged.
- *U-571* - Intense surround effects. Earthshaking bass makes a great subwoofer demo.

Films on Disc has a list of [ISF DVD citations](#) -- examples of the best of the craft.

[1.49] What do Sensormatic and Checkpoint mean?

Sensormatic and Checkpoint are two point-of-sale security systems. The names refer to the little metal tags that are inserted into DVD packaging to set off an alarm if you go through the sensors at the store entrance without having the tags deactivated during checkout. The tags are placed in the packages at the replication plant so that it doesn't have to be done at the store. This is called *source tagging*.

[1.50] What are Superbit, Infinifilm, and other variations of DVD?

There is one single DVD-Video standard. However, within the DVD-Video format there is a great deal of flexibility in the way discs can be created. Different studios have come up with brand names for their particular implementations of advanced features. There's nothing extraordinary about any particular variation, other than a studio spending a lot of time and effort making it work well and promoting it. These kinds of advanced DVDs should play on most players but may reveal more player bugs than standard discs (see [1.41](#)).

Superbit DVDs, from Columbia TriStar, use a high data rate for the video to improve picture quality. Additional language tracks and other extras are left off the disc to make room for more video data and for a DTS audio track. In most cases the difference is subtle, but it does improve the experience on high-end players and progressive-scan displays. See [superbitdvd.com](#) for marketing fluff.

Infinifilm DVDs, from New Line, let you watch a movie with pop-ups that direct you to extra content such as an interview, behind-the-scenes-footage, or historical information. See [infinifilm.com](#) for more hype.

[1.51] I don't know the parental control password for my player. What do I do?

Most DVD players allow you to lock out discs above a certain rating (see [1.42](#)). The rating level is protected by a password so that children (or spouses) can't change it. If you don't know the password you won't be able to play some discs. You might be able to clear the password by resetting the player (see the user manual) or unplugging it for a few days. In some cases you might be able to use the default password (0000, 9999, or 3308). Otherwise you'll have to call the customer service number of the manufacturer and see if they can help you. Make sure you speak in a deep voice so they don't think you are a kid trying to hack into his parents' player.

[1.52] Can my DVD player get a virus?

There's almost no chance your DVD player can be infected with a virus of the kind that infect computer software. DVD players have simple computers in them that run commands from the disc as it plays, but memory is reset when you press Stop or eject the disc. The firmware in some DVD players can be upgraded by inserting a special disc (see [1.47](#)), so it's theoretically possible someone could make a disc that damages the firmware of a player, but it's highly unlikely and would only have an effect on a few models.

[2] DVD's relationship to other products and technologies

[2.1] Will DVD replace VCRs?

Eventually. DVD player sales exceeded VCR sales in 2001. DVD recorders (see [1.14](#)) will hasten the death of VCRs once the price difference is small enough. DVDs have many advantages over tapes, such as no rewinding, quick access to any part of a recording, and fundamentally lower technology cost for hardware and disc production. Some projections show DVD recorder sales passing VCR sales in 2005. By 2010 VHS may be as dead as vinyl records were in 2000.

[2.2] Will DVD replace CD?

CD-ROMs and recordable CDs will probably never disappear since they are cheaper and can be used instead of DVD when the extra capacity isn't needed. Likewise CD audio discs will probably never be replaced by DVD-Video or DVD-Audio discs since CDs are cheap and simple to make. However, DVD-ROM drives and recordable DVD drives will eventually replace CD-ROM drives and CD-RW drives in computers. Most manufacturers plan to cease CD drive production in favor of DVD drives once they are cheap enough. Because DVD-ROM drives can read CD-ROMs, and because DVD recordable drives can write CD-R and CD-RW discs, there is a compatible forward migration path.

[2.3] Can CD-R writers create DVDs?

No. DVD uses a smaller wavelength of laser to make smaller pits in tracks that are closer together. The DVD laser must also focus more tightly and at a different level. In fact, a CD-R made on a CD-R writer may not be readable by a DVD-ROM drive (see [2.4.3](#)). It's unlikely there will be "upgrades" to convert CD-R drives to DVD-R, since this would cost more than purchasing a new DVD-R drive.

[2.4] Is CD compatible with DVD?

This is actually many questions with many answers, covered in the following sections.
[Note the differentiation between DVD (general case) and DVD-ROM (computer data).]

[2.4.1] Is CD audio (CD-DA) compatible with DVD?

Yes. All DVD players and drives will read audio CDs (Red Book). This is not actually required by the DVD spec, but so far all manufacturers have made their DVD hardware read CDs.

On the other hand, you can't play a DVD in a CD player. (The pits are smaller, the tracks are closer together, the data layer is a different distance from the surface, the modulation is different, the error correction coding is new, etc.) Also, you can't put CD audio data onto a DVD and have it play in DVD players. (Red Book audio frames are different than DVD data sectors.)

[2.4.2] Is CD-ROM compatible with DVD-ROM?

Yes. All DVD-ROM drives will read CD-ROMs (Yellow Book). Software on a CD-ROM will run fine in a DVD-ROM system.

However, DVD-ROMs are not readable by CD-ROM drives.

[2.4.3] Is CD-R compatible with DVD?

Sometimes. The problem is that most CD-Rs (Orange Book Part II) are "invisible" to DVD laser wavelength because the dye used to make the CD-R doesn't reflect the beam. Some first-generation DVD-ROM drives and many DVD players can't read CD-Rs. The formulation of dye used by different CD-R manufacturers also affects readability. That is, some brands of CD-R discs have better reflectivity at DVD laser wavelength, but even these don't reliably work in all players.

The common solution is for the DVD player or drive to use two lasers at different wavelengths: one for reading DVDs and the other for reading CDs and CD-Rs. Variations on the theme include Sony's "dual discrete optical pickup" with switchable pickup assemblies with separate optics, dual-wavelength lasers (initially deployed on Sony's Playstation 2), Samsung's "annular masked objective lens" with a shared optical path, Toshiba's similar shared optical path using an objective lens masked with a coating that's transparent only to 650-nm light, Hitachi's switchable objective lens assembly, and Matsushita's holographic dual-focus lens. The MultiRead logo guarantees compatibility with CD-R and CD-RW media, but unfortunately, few manufacturers are using it.

Bottom line: If you want a DVD player that can read CD-R discs, look for a "dual laser," "twin laser," or "dual optics" feature.

An effort to develop CD-R "Type II" media compatible with both CD and DVD wavelengths was abandoned.

DVD-ROM drives can't record on CD-R or any other media, but a few combination DVD-ROM/CD-RW drives can write to CD-R and CD-RW. Most newer recordable DVD drives (see [4.3](#)) can also record on CD-R or CD-RW.

CD-R burners can't read or write DVD discs of any kind.

[2.4.4] Is CD-RW compatible with DVD?

Usually. CD-Rewritable (Orange Book Part III) discs have a smaller reflectivity difference, requiring new automatic-gain-control (AGC) circuitry in CD-ROM drives and CD players. Most existing CD-ROM drives and CD players can't read CD-RW discs. The OSTA MultiRead standard addresses this, and some DVD manufacturers have suggested they will support it. The optical circuitry in even first-generation DVD-ROM drives and DVD players is usually able to read CD-RW discs, since CD-RW does not have the "invisibility" problem of CD-R (see [2.4.3](#)).

Most newer recordable DVD drives (see [4.3](#)) can also record on CD-R or CD-RW.

CD-RW burners can't read or write DVD discs of any kind.

[2.4.5] Is Video CD compatible with DVD?

Sometimes. It's not required by the DVD spec, but it's trivial to support the Video CD (White Book) standard since any MPEG-2 decoder can also decode MPEG-1 from a Video CD. About two thirds of DVD players can play Video CDs. Most Panasonic, RCA, Samsung, and Sony models play Video CDs. Japanese Pioneer models play Video CDs but American models older than the DVL-909 don't. Toshiba players older than models 2100, 3107, and 3108 don't play Video CDs.

VCD resolution is 352x288 for PAL and 352x240 for NTSC. The way most DVD players and Video CD players deal with the difference is to chop off the extra lines or add blank lines. When playing PAL VCDs, the Panasonic and RCA NTSC players apparently cut 48 lines (17%) off the bottom. Sony NTSC players scale all 288 lines to fit.

Because PAL VCDs are encoded for 25 fps playback of 24 fps film, there is usually a 4% speedup. Playing time is shorter, and the audio is shifted up in pitch unless it was digitally processed before encoding to shift the pitch back to normal. This also happens with PAL DVDs (see [1.19](#)).

All DVD-ROM computers can play Video CDs (with the right software).

Standard VCD players can't play DVDs.

Note: Many Asian VCDs carry two soundtracks by putting one language on the left channel and another on the right. The two channels are mixed together into a stereo system unless you adjust the balance or disconnect one input to get only one channel.

For more on Video CD, see Glenn Sanderse's [Video CD FAQ](#) at [CDPage](#), or Russil Wvong's [Video CD FAQ](#).

[2.4.6] Is Super Video CD compatible with DVD?

Not generally. Super Video CD (SVCD) is an enhancement to Video CD that was developed by a Chinese government-backed committee of manufacturers and researchers, partly to sidestep DVD technology royalties and partly to create pressure for lower DVD player and disc prices in China. The final SVCD spec was announced in September 1998, winning out over C-Cube's China Video CD (CVD) and HQ-VCD (from the developers of the original Video CD). In terms of video and audio quality, SVCD is in between Video CD and DVD, using a 2x CD drive to support 2.2 Mbps VBR MPEG-2 video (at 480x480 NSTC or 480x576 PAL resolution) and 2-channel MPEG-2 Layer II audio. As with DVD, it can overlay graphics for subtitles. It's technically easy to make a DVD-Video player compatible with SVCD, but it's being done mostly on Asian DVD player models. The Philip's DVD170 player can be upgraded (using a special disc) to play SVCD discs.

SVCD players can't play DVDs, since the players are based on CD drives.

See Jukka Aho's [Super Video CD Overview](#) and [Super Video CD FAQ](#) for more info.

[2.4.7] Is Picture CD or Photo CD compatible with DVD?

Sometimes. Because Picture CDs and Photo CDs are usually on CD-R media, they suffer from the CD-R problem (see [2.4.3](#)). That aside, some DVD players can play Picture CDs. Only a few can play Photo CDs.

Most DVD-ROM drives will read Picture CDs or Photo CDs (if they read CD-Rs) since it's trivial to support the XA and Orange Book multisession standards. Picture CDs are designed to work with Windows. Photo CDs require specific support from an application or an OS.

Photos can be put on recordable DVDs using the DVD-Video slideshow feature, which works on all DVD players. See [5.8](#).

[2.4.8] Is CD-i compatible with DVD?

In general, no. DVD players do not play CD-i (Green Book) discs. Philips once announced that it would make a DVD player that supported CD-i, but it never appeared. Some people expected Philips to create a "DVD-i" format in an attempt to breathe a little more life into CD-i (and recover a bit more of the billion or so dollars they invested in it). A DVD-ROM PC with a CD-i card should be able to play CD-i discs.

There are also "CD-i movies" that use the CD-i Digital Video format that was the precursor to Video CD. Early CD-i DV discs won't play on DVD players or VCD players, but newer CD-i movies, which use the standard VCD format, will play on any player that can play VCDs (see [2.4.5](#)).

See Jorg Kennis' [CD-i FAQ](#) for more information on CD-i.

[2.4.9] Is Enhanced CD compatible with DVD?

Yes. DVD players will play music from enhanced music CDs (Blue Book, CD Plus, CD Extra), and DVD-ROM drives will play music and read data from enhanced CDs. Older ECD formats such as mixed mode and track zero (pregap, hidden track) should also be compatible, but there is a problem with Microsoft and other CD/DVD-ROM drivers skipping track zero.

[2.4.10] Is CD+G compatible with DVD?

Only a few players, such as the Pioneer DVL-9 player and Pioneer karaoke DVD models DV-K800 and DVK-1000, support CD+G discs. Most DVD players don't support this mostly obsolete format. All DVD-ROM drives can read the CD+G information, but special software is required to make use of it.

[2.4.11] Is CDV compatible with DVD?

Sort of. CDV, sometimes called Video Single, is actually a weird combination of CD and laserdisc. Part of the disc contains 20 minutes of digital audio playable on any CD or DVD player. The other part contains 5 minutes of analog video and digital audio in laserdisc format, playable only on a CDV-compatible laserdisc player. Pioneer's combination DVD/laserdisc players are the only DVD players that can play CDVs.

Standard laserdisc/CDV players can't play DVDs. (See [2.5](#) for more LD info.)

[2.4.12] Is MP3 compatible with DVD?

Not officially. MP3 is the MPEG Layer 3 audio compression format. (MP3 is not MPEG-3, which doesn't exist.) The DVD-Video spec allows only Layer 2 for MPEG audio (MP2). However, MP3 can be played any computer with a DVD-ROM drive, and many DVD players (particularly those manufactured in Asia) can play MP3 CDs. However, most DVD players can't play MP3 DVDs, because they are shortsightedly designed to only look for MP3 files on CDs. Check the [player list](#) at DVDRHelp.com for players that can play MP3 CDs or MP3 DVDs.

[2.4.13] Is HDCD compatible with DVD?

Yes. Pacific Microsonics' [HDCD](#) (high-definition compatible digital) is an encoding process that enhances audio CDs so that they play normally in standard CD and DVD players (and allegedly sound better than normal CDs) yet produce an extra 4 bits of precision (20 bits instead of 16) when played on CD and DVD players equipped with HDCD decoders.

[2.5] Is laserdisc compatible with DVD?

No. Standard DVD players will not play laserdiscs, and you can't play a DVD disc on any standard laserdisc player. (Laserdisc uses analog video, DVD uses digital video; they are very different formats.)

Pioneer makes combo players that play laserdiscs and DVDs (and also CDVs and audio CDs).

[2.6] Will DVD replace laserdisc?

When this question was first entered in the FAQ in 1996, before DVD was available, many people wondered if DVD would replace laserdisc, the 12-inch optical disc format that had been around since 1978. Some argued that DVD would fail and its adherents would come groveling back to laserdisc. After DVD was released, it soon became clear that it had doomed laserdisc to quick obscurity. Pioneer Entertainment, the long-time champion of laserdisc, abandoned laserdisc production in the U.S. in June of 1999. This was sooner than even Pioneer thought possible (in September 1998, Pioneer's president Kaneo Ito said the company expected laserdisc products to be in the market for another one-and-a-half to two years), although Pioneer did continue to release small runs in Japan until 2001.

Laserdisc still fills niches in education, training, and video installations, but it's fading even there. Existing laserdisc players and discs will be around for a while, though essentially no new discs are being produced. There were about 18,000 laserdisc titles in the US and a total of over 35,000 titles worldwide that could be played on over 7 million laserdisc players. (See Julien Wilk's [Laserdisc Database](#) for the most extensive list of titles.) It took DVD several years to reach this level, and there are still rare titles available on laserdisc but not on DVD. One bright point is that laserdiscs can now be had at bargain prices.

[2.7] How does DVD compare to laserdisc?

- **Features:** DVD has the same basic features as CLV LD (scan, pause, search) and CAV LD (freeze, slow) and adds branching, multiple camera angles, parental control, video menus, interactivity, etc., although some of these features are not available on all discs.
- **Capacity:** Single-layer DVD holds over 2 hours, dual-layer holds over 4 hours. CLV LD holds one hour per side, CAV holds half an hour. A CAV laserdisc can hold 104,000 still images. DVD can hold thousands of still pictures accompanied by hundreds of hours of audio and text.
- **Convenience:** An entire movie fits on one side of a DVD, so there's no need to flip the disc or wait for the player to do it. DVDs are smaller and easier to handle. DVD players can be portable, similar to CD players. Discs can be easily and cheaply sent through the mail. On the other hand, laserdiscs have larger covers for better art and text.
- **Noise:** Most LD players make a whirring noise that can be heard during quiet segments of a movie. Most DVD players are as quiet as CD players.

- **Audio:** LD can have better quality on Dolby Surround soundtracks stored in uncompressed PCM format. DVD has better quality on Dolby Digital or music only (PCM). LD has 2 audio tracks: analog and digital, whereas DVD has up to 8 audio tracks. LD uses PCM audio sampled with 16 bits at 44.1 kHz. DVD LPCM audio can use 16, 20, or 24 bit samples at 48 or 96 kHz (although PCM is not used with most movies). LD has surround audio in Dolby Surround, Dolby Digital (AC-3), and DTS formats. 5.1-channel surround sound is available by using one channel of the analog track for AC-3 or both channels of the digital track for DTS. DVD uses the same Dolby Digital surround sound, usually at a higher data rate of 448 kbps, and can optionally include DTS (at data rates up to 1536 kbps compared to LD's 1411 kbps, but in practice DTS data rates are often 768 kbps). DVD players convert Dolby Digital to Dolby Surround. The downmixing, combined with the effects of compression, often results in lower-quality sound than from LD Dolby Surround tracks.
- **Video:** DVD usually has better video. LD suffers from degradation inherent in analog storage and in the composite NTSC or PAL video signal. DVD uses digital video, and even though it's heavily compressed, most professionals agree that when properly and carefully encoded it's virtually indistinguishable from studio masters. This doesn't mean that the video quality of DVD is always better than LD. Only that it can be better. Also keep in mind that the average television is of insufficient quality to show much difference between LD and DVD. Home theater systems or HDTVs are needed to take full advantage of the improved quality.
- **Resolution:** In numerical terms DVD has 345,600 pixels (720x480), which is 1.3 times LD's approximately 272,160 pixels (567x480). Widescreen DVD has 1.7 times the pixels of letterboxed LD (or 1.3 times anamorphic LD). As for lines of horizontal resolution, DVD has about 500 whereas LD has about 425 (more info in [3.4.1](#)). In analog output signal terms, typical luma frequency response maintains full amplitude to between 5.0 and 5.5 MHz. This is below the 6.75 MHz native frequency of the MPEG-2 digital signal. Chroma frequency response is one-half that of luma. Laserdisc frequency response usually begins to fall off at 3 MHz. (All figures are for NTSC, not PAL.)
- **Legacy titles:** Some movies on laserdisc will probably never appear on DVD (see Julien Wilk's [Laserdisc Database](#)).
- **Availability:** DVD players and discs are available for purchase and rental in thousands of outlets and on the Internet. LD players and discs are becoming hard to find.
- **Price:** Low-cost DVD players are cheaper than the cheapest LD player. Most movies on DVD cost less than on LD.
- **Restrictions:** For those outside the US, regional coding (see [1.10](#)) is a definite drawback of DVD. For some people Macrovision copy protection (see [1.11](#)) is an annoyance. Laserdisc has no copy protection and does not have regional differences other than PAL vs. NTSC.
- **Recordable:** DVD recorders are increasingly affordable. Laserdisc recording, at a low of \$250 per disc, was never available to general consumers.

For more laserdisc info, see Leopold's FAQ at <www.cs.tut.fi/~leopold/Ld/FAQ/index.html>, and Bob Niland's FAQs and overview at <www.access-one.com/rjn/laser/laserdisc.html> (overview reprinted from Widescreen Review magazine).

[2.8] Can I modify or upgrade my laserdisc player to play DVD?

No. DVD circuitry is completely different, the pickup laser is a different wavelength, the tracking control is more precise, etc. No hardware upgrades have been announced, and in any case they would be more expensive than buying a DVD player to put next to the laserdisc player.

[2.9] Does DVD support HDTV (DTV)? Will HDTV make DVD obsolete?

Short answers: Partially. No.

First, some quick definitions: HDTV (high-definition TV) encompasses both analog and digital televisions that have a widescreen 16:9 aspect ratio and approximately 5 times the resolution of standard TV (double vertical, double horizontal, wider aspect). DTV (digital TV) applies to digital broadcasts in general and to the U.S. ATSC standard in specific. The ATSC standard includes both standard-definition (SD) and high-definition (HD) digital formats. The notation H/DTV is often used to specifically refer to high-definition digital TV.

In December of 1996 the FCC approved the U.S. DTV standard. HDTVs became available in late 1998, but they are still expensive and won't become widespread for many years. DVDs are not HD, but they look great on HDTVs. Over 80 percent of the 2 million DTV sets sold in the U.S. in 2002 did not have tuners, indicating that their owners got them for watching DVDs.

DVD-Video does not directly support HDTV. No digital HDTV standards were finalized when DVD was developed. In order to be compatible with existing televisions, DVD's MPEG-2 video resolutions and frame rates are closely tied to NTSC and PAL/SECAM video formats (see [1.19](#)). DVD does use the same 16:9 aspect ratio of HDTV and the Dolby Digital audio format of U.S. DTV.

HDTV in the U.S. is part of the ATSC DTV format. The resolution and frame rates of DTV in the US generally correspond to the ATSC recommendations for SD (640x480 and 704x480 at 24p, 30p, 60p, 60i) and HD (1280x720 at 24p, 30p, and 60p; 1920x1080 at 24p, 30p and 60i). (24p means 24 progressive frames/sec, 60i means 60 interlaced fields/sec [30 frames/sec].) The current DVD-Video spec covers all of SD except 60p. It's expected that future DVD players will output digital video signals from existing discs in SDTV formats. The HD formats are 2.7 and 6 times the resolution of DVD, and the 60p version is twice the frame rate. The ITU-R is working on BT.709 HDTV standards of 1125/60 (1920x1035/30) (same as SMPTE 240M, similar to Japan's analog MUSE HDTV) and 1250/50 (1920x1152/25) which may be used in Europe. The latter is 5.3 times the resolution of DVD's 720x576/25 format. HD maximum data rate is usually 19.4 Mbps, almost twice the maximum DVD-Video data rate. In other words, DVD-Video does not currently support HDTV video content.

HDTV will not make DVD obsolete. Those who postpone purchasing a DVD player because of HDTV are in for a long wait. It will take many years before even a small percentage of homes have HDTV sets. The [CEA](#) expects 10 percent of U.S. households to have HDTV in 2003, 20 percent by 2005, and 30 percent by 2006.

HDTV sets include analog video connectors (composite, s-video, and component) that work with all DVD players and other existing video equipment such as VCRs. Existing DVD players and discs will work perfectly with HDTV sets and provide a much better picture than any other prerecorded consumer video format, especially when using a progressive-scan player. Since the cheapest route to HDTV reception will be HDTV converters for existing TV sets, broadcast HDTV for many viewers will look no better than DVD.

HDTV displays support digital connections such as HDMI (DVI) and IEEE 1394/FireWire, although standardization is not quite finished. Digital connections for audio and video provide the best possible reproduction of DVDs, especially in widescreen mode. The DVD Forum finalized specifications for supporting 1394 and HDMI in 2002, and players with DVI/HDMI digital outputs appeared in 2003. When the DVD stream recording (SR) format is finalized, DVD-SR players may be usable as "transports" that output any kind of A/V data (even formats developed after the player was built) to different sorts of external displays or converters.

The interesting thing many people don't realize is that DTV happened sooner, faster, and cheaper on PCs. A year before any consumer DTV sets came out you could buy a DVD PC with a 34" VGA monitor and get gorgeous progressive-scan movies for under \$3000. The quality of a good DVD PC connected to a data-grade video projector can beat a \$30,000 line-doubler system. (See [BroadbandMagic](#), [Digital Connection](#), and [Sleekline](#) for product examples. Video projectors are available from [Barco](#), [Dwin](#), [Electrohome](#), [Faroudja](#), [InFocus](#), [Projectavision](#), [Runco](#), [Sharp](#), [Sony](#), [Vidikron](#), and others.)

Eventually the DVD-Video format will be upgraded to an HD-DVD format. See [2.12](#), [3.13](#) and [6.5](#).

[2.10] What is Divx?

There are two Divxes. The original was a pay-per-view version of DVD. The later claimant of the name (spelled DivX), is a video encoding format.

The original Divx

Depending on whom you ask, Divx (Digital Video Express, first known as ZoomTV) was either an insidious evil scheme for greedy studios to control what you see in your own living room or an innovative approach to video rental that would have offered cheap discs you could get almost anywhere and keep for later viewings.

Developed by Circuit City and a Hollywood law firm, Divx was supported by Disney (Buena Vista), Twentieth Century Fox, Paramount, Universal, MGM, and DreamWorks SKG, all of which also released discs in "open DVD" format, since the Divx agreement was non-exclusive. Harman/Kardon, JVC, Kenwood,

Matsushita (Panasonic), Pioneer, Thomson (RCA/Proscan/GE), and Zenith announced Divx players, though some never came to market. (Divx models are Panasonic X410, Proscan PS8680Z, RCA RC5230Z and RC5231Z, and Zenith DVX2100.) The studios and hardware makers supporting Divx were given incentives in the form of guaranteed licensing payments totaling over \$110 million. Divx discs were manufactured by Nimbus, Panasonic, and Pioneer. Circuit City lost over \$114 million (after tax writeoffs) on Divx.

Divx was a pay-per-viewing-period variation of DVD. Divx discs sold for \$4.50. Once inserted into a Divx player the disc would play normally (allowing the viewer to pause, rewind, even put in another disc before finishing the first disc) for the next 48 hours, after which the "owner" had to pay \$3.25 to unlock it for another 48 hours. A Divx DVD player, which cost about \$100 more than a regular player, had to be hooked up to a phone line so it could call an 800 number for about 20 seconds during the night once each month (or after playing 10 or so discs) to upload billing information. Most Divx discs could be converted to DivxSilver status by paying an additional fee (usually \$20) to allow unlimited plays on a single account (as of Dec 1998, 85% of Divx discs were convertible). Unlimited-playback DivxGold discs were announced but never produced. Divx players can also play regular DVD discs, but Divx discs do not play in standard DVD players. Divx discs are serialized (with a barcode in the standard Burst Cutting Area) and in addition to normal DVD copy protection (see [1.11](#)) they employ watermarking of the video, modified channel modulation, and triple DES encryption (two 56-bit keys) of serial communications. Divx technology never worked on PCs, which undoubtedly contributed to its demise. Because of the DES encryption, Divx technology may not have been allowed outside the U.S.

Divx was originally announced for summer 1998 release. Limited trials began June 8, 1998 in San Francisco, CA and Richmond, VA. The only available player was from Zenith (which at the time was in Chapter 11 bankruptcy), and the promised 150 movies had dwindled to 14. The limited nationwide rollout (with one Zenith player model and 150 movies in 190 stores) began on September 25, 1998. By the end of 1998 about 87,000 Divx players (from four models available) and 535,000 Divx discs were sold (from about 300 titles available). The company apparently counted the five discs bundled with each player, which means 100,000 additional discs were sold. By March 1999, 420 Divx titles were available (compared to over 3,500 open DVD titles). All things considered, Divx players were selling well and titles were being produced with impressive speed.

On June 16, 1999, less than a year after initial product trials, Circuit City withdrew its support and Divx announced that it was closing down. Divx did not confuse or delay development of the DVD market nearly as much as many people predicted (including yours truly). In fact, it probably helped by stimulating Internet rental companies to provide better services and prices, by encouraging manufacturers to offer more free discs with player purchases, and by motivating studios to develop rental programs.

When it closed down, the company offered \$100 rebate coupons to all owners of Divx players. This made the players a good deal, since they can play open DVDs just as well as other low-end players that cost more. On July 7th, 2001, Divx players dialed into the central billing computer, which decommissioned them. (Divx players not connected to phone lines have expired their playback allowance.) Divx discs are no longer playable in any players.

For more information see the [Divx Owner's Association](#).

Advantages of Divx:

- Viewing could be delayed, unlike rentals.
- Discs need not be returned. No late fees.
- You could watch the movie again for a small fee. Initial cost of "owning" a disc was reduced.
- Discs could be unlocked for unlimited viewing (Divx Silver), an inexpensive way to preview before deciding to purchase.
- The disc is new; no damage from previous renters.
- The "rental" market was opened up to other retailers, including mail order.
- Studios got more control over the use of their content.
- You received special offers from studios in your Divx mailbox.
- Divx players (with better quality and features than comparable players) were a steal after Divx went out of business.

Disadvantages of Divx :

- Higher player cost (about \$100 more at first, about \$50 later).
- Although discs did not have to be returned, the viewer still had to go to the effort of purchasing the disc. Cable/satellite pay per view is more convenient.
- Higher cost than for regular DVD rental (\$3 to \$7 vs. \$2 to \$4). There were few obstacles to the company raising prices later, since it had a monopoly.
- Casual quick viewing (looking for a name in the credits, playing a favorite scene, watching supplements) required paying a fee.
- Most Divx titles were pan & scan (see [3.5](#)) without extras such as foreign language tracks, subtitles, biographies, trailers, and commentaries.
- The player had to be hooked to your phone line, possibly requiring a new jack in your living room or a phone extension cable strung across it. (Players required a connection once a month or so, so you could periodically connect it to a phone line.)
- Divx couldn't be used in mobile environments, such as a van or RV, unless you took it out and connected it to a phone line about once a month.
- The Divx central computer collected information about your viewing habits, as do cable/satellite pay-per-view services and large rental chains. (According to Divx, the law did not allow them to use the information for resale and marketing.)
- Divx players included a "mailbox" for companies to send you unsolicited offers (spam).
- Those who didn't lock out their Divx player could receive unexpected bills when their kids or visitors played Divx discs.
- Divx discs wouldn't play in regular DVD players or on PCs with DVD-ROM drives. Some uninformed consumers bought Divx discs only to find they wouldn't play in their non-Divx player.
- Unlocked Silver discs would only work in players on the same account. Playback in a friend's Divx player would incur a charge. (Gold discs, which were never released, would have played without charge in all Divx players.)
- There was no market for used Divx discs.
- Divx discs became unplayable after June 2001.
- Divx players were never available outside the U.S. and Canada.

The new DivX

In March 2000, a DVD redistribution technology called DivX;-) appeared. (Yes, the smiley face was originally part of the name, which was a take-off on the original Divx format. The perpetrators should be drawn and quartered for the stupid joke, which has caused untold confusion.) DivX was originally a simple hack of Microsoft's MPEG-4 video codec, combined with MP3 audio, allowing decrypted video from a DVD to be re-encoded for downloading and playing in [Windows Media Player](#). Work on DivX evolved through [Project Mayo](#) and a version originally called DivX Deux into an open-source initiative known as OpenDivX, based on the [MPEG-4 standard](#). Out of all this came [DivXNetworks](#), a company that has turned [DivX](#) into an extensive video encoding and delivery system based on proprietary implementations of MPEG-4. A variation called [3ivx](#) has also made the jump from open source to commercial. [XviD](#) seems to be the remaining alternative that's still open source.

Some DVD players can play files encoded in DivX format. See www.divx.com/hardware.

[2.11] How can I record from DVD to videotape?

Why in the world would you want to degrade DVD's beautiful digital picture by copying it to analog tape? Especially since you lose the interactive menus and other nice features.

If you really want to copy to VHS, hook the audio/video outputs of the DVD player to the audio/video inputs of your VCR, then record the disc to tape. You'll discover that most of the time the resulting tape is

garbled and unwatchable. This is because of the Macrovision feature designed to prevent you from doing this. See [1.11](#).

[2.12] Will high-definition DVD or 720p DVD make current players and discs obsolete?

Not for a long time. HD-DVD is just becoming available. HD stands for both high density (more data on a disc) and high definition (better quality picture). The first commercial Blu-ray HD-DVD recorders appeared in Japan in April of 2003, over 7 years after DVD was introduced there. The recorders are designed for home recording only (not for playing pre-recorded HD movies), and only work with Japan's digital HD broadcast system.

New DVD formats will slowly supersede the original DVD format, but new players will play old DVD discs and will often make them look even better (with progressive-scan video and picture processing). However, new HD-DVD discs won't be playable in older DVD players (unless they are special hybrid discs in both HD and SD format). Your collection of standard DVDs will be playable for many years to come, and titles will only become "obsolete" in the sense that you might want to replace them with new high-definition versions. Consider that U.S. HDTV was anticipated to be available in 1989, yet it was not finalized until 1996 and did not appear until 1998. Has it made your current TV obsolete yet?

See [3.13](#) for more details of HD-DVD, and [6.5](#) for more on the future of DVD.

Ironically, computers supported HDTV before settop players, because 2x DVD-ROM drives coupled with appropriate playback and display hardware met the 19 Mbps data rate needed for HDTV. This led to various "720p DVD" projects, which use the existing DVD format to store video in 1280x720 or 1920x1080 resolution at 24 progressive frames per second. It's possible that 720p DVDs can be made compatible with existing players (which would only recognize and play the 480-line line data).

Note: The term [HDVD](#) has already been taken for "high-density volumetric display."

Some have speculated that a "double-headed" player reading both sides of the disc at the same time could double the data rate or provide an enhancement stream for applications such as HDTV. This is currently impossible since the track spirals go in opposite directions (unless all four layers are used). The DVD spec would have to be changed to allow reverse spirals on layer 0. Even then, keeping both sides in sync, especially with MPEG-2's variable bit rate, would require independently tracking heads, precise track and pit spacing, and a larger, more sophisticated track buffer. Another option would be to use two heads to read both layers of one side simultaneously. This is technically feasible but has no advantage over reading one layer twice as fast, which is simpler and cheaper.

See [2.9](#) for more information about HDTV and DVD.

[2.13] What effect will FMD have on DVD?

Very little, as predicted from the beginning in this FAQ. [Constellation 3D](#) ran out of money in mid 2002. The various reports of fluorescent multilayer disc (FMD) causing the early death of DVD were wildly exaggerated and not founded in reality.

Fluorescent multilayer technology, which can be used in cards or discs, aims a laser at fluorescent dye, causing it to emit light. Since it doesn't depend on reflected laser light, it's possible to create many data layers (C3D prototyped 50 layers in its lab). It can use the same 650 nm laser as DVD, so FMD drives could be made to read DVDs. In June 2000, C3D announced a program to make FMDs with 25 GB per side that would be readable by DVD drives with a "minor and inexpensive modification." C3D later said players would be available by mid 2001. FMD was very cool technology, but it was new, with no track record, developed by one small company. DVD is based on decades of optical storage technology development by dozens of companies. The monumental task of changing entire production infrastructures over to a new format was too much for C3D, even with tens of millions of dollars and some large partners.

[2.14] How does MPEG-4 affect DVD?

MPEG-4 is a video encoding standard designed primarily for low-data rate streaming video, although it's actually more efficient than MPEG-2 at DVD and HDTV data rates. MPEG-4 also provides for advanced multimedia with *media objects*, but most implementations only support simple video (*Simple Visual Profile*). There's also MPEG-4 part 10, also known as H.264 (and also known as JVT or AVC), which is an even better video encoding standard.

DVD uses MPEG-2 video encoding (see [3.4](#) for details). Standard DVD players don't recognize the MPEG-4 video format. MPEG-4 files can be stored on DVD-ROM for use on computers. For example, DivX uses MPEG-4 (see [4.8](#)).

It's possible that MPEG-4 or H.264 will be used in a future, high-definition version of DVD. In any case, it will probably not appear before 2005 at the earliest.

For more about MPEG, see Tristan's [MPEG.org](#) site and the [MPEG home page](#).

[2.15] What's WebDVD or Enhanced DVD?

WebDVD is the simple but powerful concept of combining DVD content with Internet technology. It combines the best of DVD (fast access to high-quality video, audio, and data) with the best of the Internet (interactivity, dynamic updates, and communication). In general, WebDVD refers to enhancing a DVD with HTML pages, links and scripting, or enhancing a Web site with content from a local DVD drive. WebDVD is not a trademarked term of AOL-Warner, Microsoft, or any other company. Variations on the WebDVD concept are known as iDVD, eDVD, Connected DVD, and so on. It's not a new idea --it's been done with CD-ROM for years-- but the differences with DVD are that the quality of the audio and video are finally better than TV, and the discs can be played in low-cost settop players.

Almost all WebDVD implementations are currently for PCs, but some new DVD players are adding WebDVD features. A working group of the DVD Forum is creating a standardized WebDVD format for set-top DVD players, to be known as Enhanced DVD.

Most professional authoring systems (see [5.4](#)) include rudimentary tools for adding HTML enhancements to DVD. For fancier WebDVD development there are a variety of tools; see [4.9](#).

For more on WebDVD, see Phil DeLancie's [EMedia article](#). Good examples of WebDVD sites are [Mars: The Red Planet](#), [Stargaze](#), and [DVD Demystified](#). The authors of these sites (Ralph LaBarge and Jim Taylor) encourage you to copy their code as a starting place for your own WebDVD creations. You can request a copy of the *WebDVD Demystified* disc from [DVD.Learn](#).

[2.16] What's a Nuon player?

Nuon was a specialized "media processor" chip, designed by VM Labs, that was powerful enough to play DVDs and video games. The chip was originally intended for video game consoles, but was hitched to DVD's wagon when the game market dried up and the DVD market exploded. Some DVD players from Samsung, Thomson (RCA), and Toshiba were built on Nuon technology. The extra processing power in a Nuon player enabled special features such as graphical overlays, digital zoom, and live thumbnails. Some DVD movies were produced with added content designed specifically for the Nuon platform. As of the beginning of 2002, four Nuon-enhanced DVD movies were available: *The Adventures of Buckaroo Banzai (Special Edition)*, *Bedazzled*, *Dr. Doolittle 2*, and *Planet of the Apes*.

In December 2001 VM Labs filed for Chapter 11 bankruptcy, and in March 2002 the company's assets were purchased by [Genesis Microchip](#). A new division, Nuon Semiconductor, was formed to market Nuon chips under the Aries name. On July 24, 2002, Genesis laid off the entire Nuon division. RIP.

[2.17] What effect will D-VHS have on DVD?

D-VHS (the D stands for data or digital), the digital successor to VHS tape, was first announced in 1995 but didn't appear outside of Japan until 1998. At the time D-VHS decks could only record pre-encoded bit streams such as from a digital satellite receiver. In 2001 the D-Theater format was released, which standardized MPEG compression and copy protection, paving the way for the release of pre-recorded movies on D-VHS tape in 2002. D-Theater became the first format for viable commercial distribution of movies in high-definition. Quality is excellent, with a resolution of 1280x720p (2.7 times NTSC DVD, 2.2 times PAL DVD) or 1920x1080i (roughly 4 times NTSC DVD, 3.5 times PAL DVD). However, consumers have shown a distinct preference for discs instead of tapes, so D-VHS will never become more than a niche product. Since HD-DVD began to arrive in 2003 (see [3.13](#)), consumers other than early adopters and HD aficionados are choosing to wait for the next generation of DVD for pre-recorded movies and for home recording of HD programs.

[3] DVD technical details

[3.1] What are the outputs of a DVD player?

DVD players usually have two or three kinds of video output (composite, s-video, and component) and three or four kinds of audio output (analog stereo, digital PCM stereo, Dolby Digital, and DTS). More details below and in [3.2](#).

Video outputs

Most DVD players have the following video output connections, which can carry an NTSC, PAL, or SECAM signal.

- S-video (Y/C). 4-pin round plug. Carries brightness signal (Y) and two combined color signals (C).
- Composite video (CVBS). Standard yellow RCA video plug. Combines all three video signals into one.
- European players combine both of the signals above, and others, into a 21-pin rectangular SCART connector (aka Peritel or Euro Connector [EC]).

Some players may have additional video connections:

- Component interlaced analog video (EIA 770.1). Keeps all three video signals separate.
 - Y'PbPr format: 3 RCA or BNC connectors.
 - RGB (or RGBS or RGBHV) format: SCART connector or 3, 4, or 5 RCA or BNC connectors.
- Component progressive analog video. Keeps all three video signals separate.
 - Y'PbPr format: 3 RCA connectors.
 - RGB (or RGBS or RGBHV) format: SCART connector or 3, 4, or 5 RCA or BNC connectors.
- RF video. For connecting to the TV antenna input, usually on channel 3 or 4.
 - Screw-on, 75-ohm, F-type connector. May require an adapter for TVs that have 300-ohm, two-screw, antenna wire connectors.
- DVI. Digital video output. Uses HDCP for copy-protected content.
- HDMI. Digital video in the DVI format (with HDCP), plus digital audio.

Most DVD players with component video outputs use YUV (Y'PbPr), which is incompatible with RGB equipment. European players with component video outputs usually provide RGBS (red/green/blue/sync) signals on the SCART connector. YUV to RGB transcoders are rumored to be available for \$200-\$300, but seem hard to track down. A \$700 converter is available from [avscience](#), and \$900 converter, the CVC 100, is available from [Extron](#). Converters are also available from [Altinex](#), [Kramer](#), [Monster Cable](#), and others. For progressive scan you need a converter that can handle 31.5 kHz signals. Converters from s-video are also an option (try [Markertek](#)).

Note: The correct term for analog color-difference output is **Y'Pb'Pr'**, not Y'Cb'Cr' (which is digital, not analog). To simplify things, this FAQ sometimes uses the term YUV in the generic sense to refer to analog color difference signals.

There are specialty players from companies such as [Function Communications](#), [Theta Digital](#), and [Vigatec](#) with SDI (serial digital interface) output, but they connect only to high-end or production equipment.

Audio outputs

Most DVD players have the following audio output connections.

- Analog stereo audio. May be in Dolby Surround, depending on the disc.
 - Two RCA connectors, red and white.
 - European players transmit analog stereo audio on the SCART connector.
- Digital audio with 1 to 5.1 channels. Raw digital audio in PCM, MLP, Dolby Digital (AC-3), DTS, or MPEG-2 format. Requires an amplifier/receiver with a built-in decoder (or a separate external decoder).
 - S/PDIF coax format: RCA connector. (IEC-958 Type II)
 - Toslink format: square optical connector. (EIAJ CP-340 and EIAJ CP-1201)

Some players may have additional audio connections:

- Multichannel analog audio. Requires a multichannel-ready or "Dolby Digital ready" amplifier/receiver with 6 inputs.
 - Six RCA connectors or one DB-25 connector.
- AC-3 RF audio. Only on combination LD/DVD players. Carries audio from AC-3 laserdiscs.
 - One RCA connector.
- High-resolution digital audio.
 - 1394 (FireWire): rectangular connector. Requires a receiver with 1394 audio input (and DTCP compatibility).
 - HDMI. Requires a receiver or TV with HDMI input.

Some players and receivers support only S/PDIF or only Toslink. If your player and receiver don't match, you'll need a converter such as the [Audio Authority 977 Midiman C02](#), COP 1, or [POE](#).

Some players can output 96/24 PCM audio using a non-standard variation of IEC-958 running at 6.144 Mbps instead of the normal limit of 3.1 MHz.

Note: The CSS license does not allow digital PCM output of CSS-protected material at 96 kHz. The player must downsample to 48 kHz.

[3.2] How do I hook up a DVD player?

It depends on your audio/video system and your DVD player. Most DVD players have 2 or 3 video hookup options and 3 audio hookup options. Choose the output format with the best quality (indicated below) that is supported by your video and audio systems. See [3.1](#) for output connector details.

On many TVs you will need to switch the TV to auxiliary input (line input). You might need to tune it to channel 0 to make this happen.

If you want to hook multiple devices (DVD player, VCR, cable/satellite box, WebTV, and so on) to a single TV, you need one of the following:

- a TV with multiple inputs
- a manual audio/video switchbox (~\$30 at electronics suppliers such as [Comtrad](#))
- an A/V receiver (to switch between video sources via remote control). If you plan on getting an A/V receiver, make sure it can handle the video format you want to use (component or s-video).

Video hookup (pick one from the list)

- **S-video** (good quality): Almost all DVD players have s-video output. S-video looks much better than composite video and is only slightly inferior to component video. Hook an s-video cable from the player to the display (or to an A/V receiver that can switch s-video). The round, 4-pin connector may be labeled Y/C, s-video, or S-VHS. If you're in Europe, you can use a SCART cable.
- **Composite video** (ok quality): All DVD players have standard RCA (Cinch) baseband video connectors or a SCART connector (in Europe) to carry composite video. Hook a standard video cable or a SCART cable from the player to the display (or to an A/V receiver to switch the video). The RCA video connectors are usually yellow and may be labeled video, CVBS, composite, or baseband.
- **Component video** (better quality): Some U.S. and Japanese players have interlaced component YUV (Y'PbPr) video output. Connectors may be labeled YUV, color difference, YPbPr, or Y/B-Y/R-Y, and may be colored green/blue/red. (Some players incorrectly label the output as YCbCr.) Some players have RGB component video output via a SCART connector or 3 RCA or BNC connectors labeled R/G/B. Hook cables from the three video outputs of the player to the three video inputs of the display, or hook a SCART cable from the player to the display.
Note: There is no standardization of the output interface format (voltage and setup). Players apparently use SMPTE 253M (286 mV sync, 0% luma setup with 700 mV peak, +/-300 mV color excursion), Betacam (286 mV sync, 7.5% luma setup with 714 mV peak, +/-350 mV color excursion), M-II (300 mV sync, 7.5% luma setup with 700 mV peak, +/-324.5 mV color excursion), or non-standard variations. Note that outputs with zero IRE setup can provide a wider

range of luma values for a slightly better picture. For equipment with RGB input, a YUV converter is usually needed. See section [3.1](#).

- **Progressive video** (even better quality): A few players have progressive-scan YUV (Y'Pb'Pr') or RGB (European players only) component video output. Hook decent-quality cables from the three video outputs of the player to the three video inputs of a progressive-scan line multiplier or a progressive-scan TV, or use a SCART cable if you have a European player and progressive-scan TV with the right connectors. Toshiba calls progressive scan ColorStream PRO. Progressive video preserves the progressive nature of most movies, providing a film-like, flicker-free image with improved vertical resolution and smoother motion. DVD computers can also produce progressive video from DVD. In this case, use a 15-pin computer video cable to connect the VGA output of the PC to the VGA input of a monitor or projector. If the projector only has RGB or YPbPr inputs, you'll need a converter such as the [Audio Authority 9A60](#). See [1.40](#), [2.12](#), and [4.1](#) for more information on progressive video.
- **Digital video** (best quality). A few players have [HDMI](#) (DVI) or [1394](#) digital outputs. This preserves the true digital signal from the DVD. Hook an HDMI or 1394 cable from the output of the player to the HDMI or 1394 input of a digital television or other digital A/V system. The same cable carries the digital audio signal.
- **RF video** (worst quality): You should use this connection only if you have an old TV that has only a screw-on antenna input. Most DVD players don't have RF output, so you will probably need to buy an RF modulator (~\$30 at [Radio Shack](#) or [Comtrad](#) or [Markertek](#)). But first see the warning below about using a VCR as an RF modulator. If the player has built-in RF output it will include audio, although it may only be mono. Connect a coax cable from the yellow video output of the player to the input of the modulator. If you are not hooking the player up to a separate stereo system, then connect a coax cable from the left audio output of the player to the audio input of the modulator. (If you have a stereo modulator, connect another cable for the right audio channel.) Connect a coax antenna cable from the modulator to the TV. You may need a 300 ohm to 75 ohm adapter (to switch between a two-wire antenna connection and a threaded coax connection). Tune the TV to channel 3 or 4 (or channel 36 in Germany and some other European countries) and set the switch on the modulator or the back of the player to match. If you also want to hook up a VCR, connect an antenna cable from the output of the VCR to the antenna input of the modulator.

Warning: If you connect your DVD player to a VCR and then to your TV (or to a combination TV/VCR), you will probably have problems with discs that enable the player's Macrovision circuit. See [3.2.1](#).

Warning: Some video projectors don't recognize the 4.43 NTSC signal from NTSC discs in PAL players (see [1.19](#)). They see the 60Hz scanning frequency and switch to NSTC even though the color subcarrier is in PAL format.

Note: Most DVD players support widescreen signaling, which tells a widescreen display what the aspect ratio is so that it can automatically adjust. One standard (ITU-R BT.1119, used mostly in Europe) includes information in a video scanline. Another standard, for Y/C connectors, adds a 5V DC signal to the chroma line to designate a widescreen signal. Unfortunately, some switchers and amps throw away the DC component instead of passing it on to the TV.

For more information on conversions between formats, see the amazing [Notes on Video Conversion](#) from the Sci.Electronics.Repair FAQ.

Audio hookup (pick one from the list)

Note: All DVD players have a built-in 2-channel Dolby Digital (AC-3) decoder. Some can also decode MPEG audio or DTS audio. The decoder translates multichannel audio into 2-channel PCM audio. This goes to the digital output and is also converted to analog for standard audio output. Some players have a built-in multichannel Dolby Digital decoder, but it's only useful if you have an audio system with multichannel analog inputs. See [3.6.3](#) for more explanation.

- **Analog audio (2-channel stereo/surround)** (ok quality): All DVD players include two RCA connectors for stereo output. Any disc with multichannel audio is automatically decoded and downmixed to 2-channel Dolby Surround output for connection to a regular stereo system or a Dolby Surround/Pro Logic system. Connect two audio cables between the player and a receiver, amplifier, or TV. Connectors may be labeled "audio" or "left/right;" left is usually white, right is usually red. If your TV has only one audio input, connect the left channel from the DVD player. If your DVD player has multichannel analog outputs (left/center/right/left rear/right rear), do not

connect them to a stereo system with only two inputs or you will lose center and rear audio — use the 2-channel left/right outputs instead.

- **Digital audio** (best quality): Almost all DVD players have digital audio outputs. The same output can carry Dolby Digital (AC-3), PCM audio (including PCM from CDs), DTS, MPEG-2 audio (PAL/SECAM players only), and MLP audio (from DVD-Audio discs). For PCM, a digital receiver or an outboard DAC is required. For all other formats, the appropriate decoder is required in the receiver/amplifier or as a separate audio processor. For example, to play a disc with a Dolby Digital soundtrack using a digital audio connection, the receiver has to have the Dolby Digital feature. DTS discs require a player with the "DTS Digital Out" mark (older players don't recognize DTS tracks) and the DTS decoding feature in the receiver. (All DVD players can play DTS CDs if a DTS decoder is connected to the digital PCM output signal.) Some DVD players have coax connectors (SP/DIF), some have fiber-optic connectors (Toslink), and many have both. There are endless arguments over which of these is better. Coax seems to have more advocates, since it's inherently simpler. Optical cable is not affected by electromagnetic interference, but it's more fragile and can't curve tightly. Suffice it to say that since the signal is digital, a quality cable of either type will provide similar results. Hook a 75-ohm coax cable or a fiber-optic cable between the player and the receiver. (You might need a converter, see [3.1](#).) Some players provide separate connectors for Dolby Digital/DTS/MPEG and for PCM. On others, you may need to select the desired output format using the player setup menu or a switch on the back of the player. If you try to feed Dolby Digital or DTS to digital receiver that doesn't recognize it, you'll get no audio.
Note: Make sure you use a quality cable; a cheap RCA patch cable may cause the audio to sound poor or not work at all.
Note: Connecting to the AC-3/RF (laserdisc) input of a receiver will not work unless your receiver can autoswitch, since DVD digital audio is not in RF format (see below).
- **Component analog audio** (excellent quality): Some players provide 6-channel analog output from the internal Dolby Digital or DTS decoder. A few provide 7-channel output from 6.1 tracks. The digital-to-analog conversion quality in the player may be better or worse than in an external decoder. A receiver/amplifier with 6 or 7 inputs (or more than one amplifier) is required; this type of unit is often called "Dolby Digital ready" or "AC-3 ready." Unfortunately, in many cases you won't be able to adjust the volume of individual channels or perform bass management. Hook 6 (or 7) audio cables to the RCA connectors on the player and to the matching connectors on the receiver/amplifier. Some receivers require an adapter cable with a DB-25 connector on one end and RCA connectors on the other.
Note: Until there is a digital connection standard, the only way to get multichannel PCM output from DVD-Audio players will be with analog connections or proprietary connections. If you plan to get a DVD-Audio player, you'll need a receiver with analog multichannel inputs.
- **RF digital audio** (laserdisc only): Combination LD/DVD players include AC-3 RF output for digital audio from laserdiscs. Hook a coax cable to the AC-3 RF input of the receiver/processor. *Note:* digital audio from DVDs does not come out of the RF output, it comes out of the optical/coax outputs. Analog audio from LDs will come out the stereo connectors, so three separate audio hookups are required to cover all variations.

[3.2.1] Will I have problems connecting my VCR between my TV and my DVD player?

It's not a good idea to route the video from your DVD player through your VCR. Most movies use Macrovision protection (see [1.11](#)), which affects VCRs and causes problems such as a repeated darkening and lightening of the picture. If your TV doesn't have a direct video input, you may need a separate RF converter (see [3.2](#)). Or better yet, get a new TV with direct video inputs.

You may also have problems with a TV/VCR combo, since many of them route the video input through the VCR circuitry. The best solution is to get a box to strip Macrovision (see [1.11](#)).

[3.2.2] Why is the audio or video bad?

The number one cause of bad video is a poorly adjusted TV. The high fidelity of DVD video demands much more from the display. Turn the sharpness and brightness down. See [1.3](#) for more information. For technical details of TV calibration, see Anthony Haukap's [FAQ: How To Adjust a TV](#).

If you get audio hum or noisy video, it's probably caused by interference or a ground loop. Try a different set of cables. Try a shorter cable. (Long cables can degrade the signal.) Make sure the cables are good quality with shielding. Try turning off all equipment except the pieces you are testing. Try moving things farther apart. Try plugging into a different circuit. Make sure all equipment is plugged into the same outlet. If all else fails, ground your braces and wrap your entire house in tinfoil. For more on ground loops, see <www.hut.fi/Misc/Electronics/docs/groundloop/>. More information for repair technicians is available at [Shophelper](#).

Video or audio problems can also be caused by a faulty player or bad disc (see [1.41](#).) If the video freezes or breaks up, it may be caused by scratches on the disc (see [1.39](#)). It's normal for DVDs to freeze for a fraction of a second in the middle of a movie -- this is a layer break (see [1.27](#)).

[3.3] What are the sizes and capacities of DVD?

There are many variations on the DVD theme. Discs come in two physical sizes: 12 cm (4.7 inches) and 8 cm (3.1 inches), both 1.2 mm thick, made of two 0.6mm substrates glued together. These are the same form factors as CD. A DVD disc can be single-sided or double-sided. Each side can have one or two layers of data. The amount of video a disc can hold depends on how much audio accompanies it and how heavily the video and audio are compressed. The oft-quoted figure of 133 minutes is apocryphal: a DVD with only one audio track easily holds over 160 minutes, and a single layer can actually hold up to 9 hours of video and audio if it's compressed to VHS quality.

At a rough average rate of 5 Mbps (4 Mbps for video and 1 Mbps for two or three tracks of audio), a single-layer DVD can hold a little over two hours. A dual-layer disc can hold a two-hour movie at an average of 9.5 Mbps (close to the 10.08 Mbps limit).

A DVD-Video disc containing mostly audio can play for 13 hours (24 hours with dual layers) using 48/16 PCM (slightly better than CD quality). It can play 160 hours of audio (or a whopping 295 hours with dual layers) using Dolby Digital 64 kbps compression of monophonic audio, which is perfect for audio books.

Capacities of DVD:

For reference, a CD-ROM holds about 650 megabytes, which is 0.64 gigabytes or 0.68 billion bytes. In the list below, SS/DS means single-sided/double-sided, SL/DL/ML means single-layer/dual-layer/mixed-layer (mixed means single layer on one side, dual layer on the other side), gig means gigabytes (2^{30}), BB means billions of bytes (10^9). See note about giga vs. billion in section [7.2](#).

DVD-5 (12 cm, SS/SL)	4.37 gig (4.70 BB) of data, over 2 hours of video
DVD-9 (12 cm, SS/DL)	7.95 gig (8.54 BB), about 4 hours
DVD-10 (12 cm, DS/SL)	8.74 gig (9.40 BB), about 4.5 hours
DVD-14 (12 cm, DS/ML)	12.32 gig (13.24 BB), about 6.5 hours
DVD-18 (12 cm, DS/DL)	15.90 gig (17.08 BB), over 8 hours
DVD-1 (8 cm, SS/SL)	1.36 gig (1.46 BB), about half an hour
DVD-2 (8 cm, SS/DL)	2.47 gig (2.66 BB), about 1.3 hours
DVD-3 (8 cm, DS/SL)	2.72 gig (2.92 BB), about 1.4 hours
DVD-4 (8 cm, DS/DL)	4.95 gig (5.32 BB), about 2.5 hours
DVD-R 1.0 (12 cm, SS/SL)	3.68 gig (3.95 BB)
DVD-R 2.0 (12 cm, SS/SL)	4.37 gig (4.70 BB)
DVD-R 2.0 (12 cm, DS/SL)	8.75 gig (9.40 BB)
DVD-RW 2.0 (12 cm, SS/SL)	4.37 gig (4.70 BB)
DVD-RW 2.0 (12 cm, DS/SL)	8.75 gig (9.40 BB)
DVD+R 2.0 (12 cm, SS/SL)	4.37 gig (4.70 BB)
DVD+R 2.0 (12 cm, DS/SL)	8.75 gig (9.40 BB)
DVD+RW 2.0 (12 cm, SS/SL)	4.37 gig (4.70 BB)
DVD+RW 2.0 (12 cm, DS/SL)	8.75 gig (9.40 BB)
DVD-RAM 1.0 (12 cm, SS/SL)	2.40 gig (2.58 BB)
DVD-RAM 1.0 (12 cm, DS/SL)	4.80 gig (5.16 BB)
DVD-RAM 2.0 (12 cm, SS/SL)	4.37 gig (4.70 BB)*

DVD-RAM 2.0 (12 cm, DS/SL)	8.75 gig (9.40 BB)*
DVD-RAM 2.0 (8 cm, SS/SL)	1.36 gig (1.46 BB)*
DVD-RAM 2.0 (8 cm, DS/SL)	2.47 gig (2.65 BB)*
CD-ROM (12 cm, SS/SL, 74 minutes)	0.635 gig (0.682 BB)
CD-ROM (12 cm, SS/SL, 80 minutes)	0.687 gig (0.737 BB)
CD-ROM (8 cm, SS/SL)	0.180 gig (0.194 BB)
DDCD-ROM (12 cm, SS/SL)	1.270 gig (1.364 BB)
DDCD-ROM (8 cm, SS/SL)	0.360 gig (0.387 BB)

* Formatted DVD-RAM discs have slightly less than stated capacity. For example, the contents of a completely full DVD-R will not quite fit on a DVD-RAM.

Tip: It takes about two gigabytes to store one hour of average video.

The increase in capacity from CD-ROM is due to: 1) smaller pit length (~2.08x), 2) tighter tracks (~2.16x), 3) slightly larger data area (~1.02x), 4) more efficient channel bit modulation (~1.06x), 5) more efficient error correction (~1.32x), 6) less sector overhead (~1.06x). Total increase for a single layer is about 7 times a standard CD-ROM. There's a slightly different explanation at www.mpeg.org/MPEG/DVD/General/Gain.html.

The capacity of a dual-layer disc is slightly less than double that of a single-layer disc. The laser has to read "through" the outer layer to the inner layer (a distance of 20 to 70 microns). To reduce inter-layer crosstalk, the minimum pit length of both layers is increased from 0.4 um to 0.44 um. To compensate, the reference scanning velocity is slightly faster, 3.84 m/s, as opposed to 3.49 m/s for single layer discs. Longer pits, spaced farther apart, are easier to read correctly and are less susceptible to jitter. The increased length means fewer pits per revolution, which results in reduced capacity per layer.

Note: Older versions of Windows that use FAT16 instead of UDF, FAT32, or NTFS to read a DVD may run into problems with the 4 gigabyte volume size limit. FAT16 also has a 2 gigabyte file size limit, while FAT32 has a 4 gigabyte file size limit. (NTFS has a 2 terabyte limit, so we're ok there for a while.)

See [4.3](#) for details of writable DVD. More info on disc specifications and manufacturing can be found at [Discronics](#), [Cinram](#), [Technicolor](#), and other disc replicator sites.

[3.3.1] When did double-sided, dual-layer discs (DVD-18) become available?

These super-size discs are used for data but are not commonly used for movies. The first commercial DVD-18 title, *The Stand*, was released in October 1999. A DVD-18 requires a completely different way of creating two layers. A single-sided, dual-layer disc (DVD-9) is produced by putting one data layer on each substrate and gluing the halves together with transparent adhesive so that the pickup laser can read both layers from one side. But in order to get four layers, each substrate needs to hold two. This requires stamping a second data layer on top of the first, a much more complicated prospect. Only a few replicators can make DVD-18s, and the low yield (number of usable discs in a batch) makes it more difficult and expensive than making DVD-9s.

(My prediction in this FAQ, in December 1998, was that we wouldn't see commercial DVD-18 discs until fall 1999, in spite of many rumors that they would appear sooner.)

[3.4] What are the video details?

DVD-Video is an application of DVD-ROM, according to the specification created by the DVD Forum (see [6.1](#)). DVD-Video is also an application of MPEG-1, MPEG-2, Dolby Digital, DTS, and other formats. This means the DVD-Video format defines subsets of these standards and formats to be applied in practice to make discs intended for DVD-Video players. DVD-ROM can contain any desired digital information, but DVD-Video is limited to certain data types designed for television reproduction.

A disc has one track (stream) of MPEG-2 constant bit rate (CBR) or variable bit rate (VBR) compressed digital video. A restricted version of MPEG-2 Main Profile at Main Level (MP@ML) is used. SP@ML is also supported. MPEG-1 CBR and VBR video is also allowed. 525/60 (NTSC, 29.97 interlaced frames/sec) and 625/50 (PAL/SECAM, 25 interlaced frames/sec) video display systems are expressly supported. Coded frame rates of 24 fps progressive from film, 25 fps interlaced from PAL video, and 29.97 fps interlaced from NTSC video are typical. MPEG-2 progressive_sequence is not allowed, but interlaced sequences can

contain progressive pictures and progressive macroblocks. In the case of 24 fps source, the encoder embeds MPEG-2 repeat_first_field flags into the video stream to make the decoder either perform 2-3 pulldown for 60Hz NTSC displays (actually 59.94Hz) or 2-2 pulldown (with resulting 4% speedup) for 50Hz PAL/SECAM displays. In other words, the player doesn't "know" what the encoded rate is, it simply follows the MPEG-2 encoder's instructions to produce the predetermined display rate of 25 fps or 29.97 fps. This is one of the main reasons there are two kinds of discs, one for NTSC and one for PAL. (Very few players convert from PAL to NTSC or NTSC to PAL. See [1.19](#).)

Because film transfers for NTSC and PAL usually use the same coded picture rate (24 fps) but PAL resolution is higher, the PAL version takes more space on the disc. The raw increase before encoding is 20% (480 to 576), but the final result is closer to 15%, depending on encoder efficiency. This translates to an increase of 600 to 700 megabytes on PAL discs compared to NTSC discs.

It's interesting to note that even interlaced source video can be rendered as progressive-structured MPEG pictures by a good encoder, with interlaced field-encoded macroblocks used only when needed for motion. Most film sources are encoded at 24 frames per second (the inverse telecine process during encoding removes duplicate 2-3 pulldown fields from the videotape source, and the remaining field pairs, although technically in interlaced form, can be re-interleaved by a progressive player). Most video sources are encoded at 25 or 30 interlaced frames per second. These may be mixed on the same disc, such as an interlaced-source logo followed by a progressive-source movie.

See [3.8](#) for an explanation of progressive and interlaced scanning. See [1.40](#) for progressive-scan players. See the MPEG page <www.mpeg.org> for more information on MPEG-2 video.

Picture dimensions are at maximum 720x480 (for 525/60 NTSC display) or 720x576 (for 625/50 PAL/SECAM display). Pictures are subsampled from 4:2:2 ITU-R BT.601 down to 4:2:0 before encoding, allocating an average of 12 bits/pixel in Y'CbCr format. (Color depth is 24 bits, since color samples are shared across 4 pixels.) DVD pixels are not square (see [3.5](#)). The uncompressed source is 124.416 Mbps for video source (720x480x12x30 or 720x576x12x25), or 99.533 or 119.439 Mbps for film source (720x480x12x24 or 720x576x12x24). In analog output terms, lines of horizontal resolution is usually around 500, but can go up to 540 (see [3.4.1](#)). Typical luma frequency response maintains full amplitude to between 5.0 and 5.5 MHz. This is below the 6.75 MHz native frequency of the MPEG-2 digital signal (in other words, most players fall short of reproducing the full quality of DVD). Chroma frequency response is half that of luma.

Allowable picture resolutions are:

MPEG-2, 525/60 (NTSC): 720x480, 704x480, 352x480, 352x240

MPEG-2, 625/50 (PAL): 720x576, 704x576, 352x576, 352x288

MPEG-1, 525/60 (NTSC): 352x240

MPEG-1, 625/50 (PAL): 352x288

Different players use different numbers of bits for the video digital-to-analog converter, with the best-quality players using 10 or 12 bits. This has nothing to do with the MPEG decoding process, since each original component signal is limited to 8 bits per sample. More bits in the player provide more "headroom" and more signal levels during digital-to-analog conversion, which can help produce a better picture.

Maximum video bit rate is 9.8 Mbps. The "average" video bit rate is around 4 Mbps but depends entirely on the length, quality, amount of audio, etc. This is a 31:1 reduction from uncompressed 124 Mbps video source (or a 25:1 reduction from 100 Mbps film source). Raw channel data is read off the disc at a constant 26.16 Mbps. After 8/16 demodulation it's down to 13.08 Mbps. After error correction the user data stream goes into the track buffer at a constant 11.08 Mbps. The track buffer feeds system stream data out at a variable rate of up to 10.08 Mbps. After system overhead, the maximum rate of combined elementary streams (audio + video + subpicture) is 10.08. MPEG-1 video rate is limited to 1.856 Mbps with a typical rate of 1.15 Mbps.

Still frames (encoded as MPEG I-frames) are supported and can be displayed for a specific amount of time or indefinitely. These are used for menus or slideshows. Still frames can be accompanied by audio.

A disc also can have up to 32 subpicture streams that overlay the video for subtitles, captions for the hard of hearing, captions for children, karaoke, menus, simple animation, etc. These are full-screen, run-length-encoded bitmaps with two bits per pixel, giving four color values and four transparency values. For each group of subpictures, four colors are selected from a palette of 16 (from the YCbCr gamut), and four contrast values are selected out of 16 levels from transparent to opaque. Since one of the four values is usually 100% transparency (to let the video show through), only three combinations of colors and transparencies are left, making overlay graphics rather crude. Subpicture display command sequences

can be used to create effects such as scroll, move, color/highlight, and fade. The maximum subpicture data rate is 3.36 Mbps, with a maximum size per frame of 53220 bytes.

In addition to subtitles in subpicture streams, DVD also supports NTSC Closed Captions. Closed Caption text is stored in the video stream as MPEG-2 user data (in packet headers) and is regenerated by the player as a line-21 analog waveform in the video signal, which then must be decoded by a Closed Caption decoder in the television. Although the DVD-Video spec mentions NTSC only, there is no technical reason PAL/SECAM DVD players could not be made to output the Closed Caption text in World System Teletext (WST) format; the only trick is to deal with frame rate differences. Unfortunate note: DVD Closed Caption MPEG-2 storage format is slightly different than the ATSC format. See [1.45](#) for more about Closed Captions.

[3.4.1] What does "lines of resolution" mean?

Everyone gets confused by the term "lines of horizontal resolution," also known as LoHR or TVL. It's a carryover from analog video, it's poorly understood, and it's inconsistently measured and reported by manufacturers, but we're stuck with it until all video is digital and we can simply report resolution in pixels.

Technically, lines of horizontal resolution refers to *visually resolvable vertical lines per picture height*. In other words, it's measured by counting the number of vertical black and white lines that can be distinguished an area that is as wide as the picture is high. The idea is to make the measurement independent of the aspect ratio. Lines of horizontal resolution applies both to television displays and to signal formats such as that produced by a DVD player. Most TVs have ludicrously high numbers listed for their horizontal resolution.

Since DVD has 720 horizontal pixels (on both NTSC and PAL discs), the horizontal resolution can be calculated by dividing 720 by 1.33 (from the 4:3 aspect ratio) to get 540 lines. On a 1.78 (16:9) display, you get 405 lines. In practice, most DVD players provide about 500 lines instead of 540 because of filtering and low-quality digital-to-analog converters. VHS has about 230 (172 widescreen) lines, broadcast TV has about 330 (248 widescreen), and laserdisc has about 425 (318 widescreen).

Don't confuse lines of horizontal resolution (resolution along the x axis) with scan lines (resolution along the y axis). DVD produces exactly 480 scan lines of active picture for NTSC and 576 for PAL. The NTSC standard has 525 total scan lines, but only 480 to 483 or so are visible. (The extra lines contain sync pulses and other information, such as the Closed Captions that are encoded into line 21). PAL has 625 total scan lines, but only about 576 to 580 are visible. Since all video formats (DVD, VHS, LD, broadcast, and so on) have the same number of scan lines, it's the horizontal resolution that makes the big difference in picture quality.

For more information, see Allan Jayne's [TV and Video Resolution Explained](#).

[3.5] What's widescreen? How do the aspect ratios work?

Video can be stored on a DVD in 4:3 format (standard TV shape) or 16:9 (widescreen). The width-to-height ratio of standard televisions is 4 to 3; in other words, 1.33 times wider than high. New widescreen televisions, specifically those designed for HDTV, have a ratio of 16 to 9; that is, 1.78 times wider than high.

DVD is specially designed to support widescreen displays. Widescreen 16:9 video, such as from a 16:9 video camera, can be stored on the disc in *anamorphic* form, meaning the picture is squeezed horizontally to fit the standard 4:3 rectangle, then unsqueezed during playback.

Things get more complicated when film is transferred to video, since most movies today have an aspect ratio of 1.66, 1.85 ("flat"), or 2.40 ("scope"). Because these don't match 1.33 or 1.78 TV shapes, two processes are employed to make various movie pegs fit TV holes:

Letterbox (often abbreviated to LBX) means the video is presented in its theatrical aspect ratio, which is wider than standard or widescreen TV. Black bars, called *mattes*, are used to cover the gaps at the top and bottom. A 1.85 movie that has been letterboxed for 1.33 display has thinner mattes than a 2.4 movie letterboxed to 1.33 (28% of display height vs. 44%), although the former are about the same thickness as those of a 2.4 movie letterboxed to 1.78 (26% of display height). The mattes used to letterbox a 1.85 movie for 1.78 display are so thin (2%) that they're hidden by the overscan of most widescreen TVs. Some movies, especially animated features and European films, have an aspect ratio of 1.66, which can be letterboxed for 1.33 display or *sideboxed* (*windowboxed*) for 1.78 display.

Pan & scan means the thinner TV "window" is panned and zoomed across the wider movie picture, chopping off the sides. However, most movies today are shot *soft matte*, which means a full 1.33 aspect film frame is used. (The cinematographer has two sets of frame marks in her viewfinder, one for 1.33 and one for 1.85, so he or she can allow for both formats.) The top and bottom are masked off in the theater, but when the film is transferred to video the full 1.33 frame can be used in the pan & scan process. Pan & scan is primarily used for 1.33 formatting, not for 1.78 formatting, since widescreen fans prefer that letterboxing be used to preserve the theatrical effect.

For more details and nice visual aids see Leopold's [How Film Is Transferred to Video](#) page.

Once the video is formatted to fullscreen or widescreen form, it's encoded and stored on DVD discs. DVD players have four playback modes, one for 4:3 video and three for 16:9 video:

- full frame (4:3 video for 4:3 display)
- auto letterbox (16:9 anamorphic video for 4:3 display)
- auto pan & scan (16:9 anamorphic video for 4:3 display)
- widescreen (16:9 anamorphic video for 16:9 display)

Video stored in 4:3 format is not changed by the player. It appears normally on a standard 4:3 display. Widescreen systems either enlarge it or add black bars to the sides. 4:3 video may have been formatted with letterboxing or pan & scan before being transferred to DVD. All formatting done to the video prior to it being stored on the disc is transparent to the player. It merely reproduces it as a standard 4:3 TV picture. Video that is letterboxed before being encoded can be flagged so that the player will tell a widescreen TV to automatically expand the picture. Unfortunately, some discs (such as *Fargo*) do not flag the video properly. And worse, some players ignore the flags.

The beauty of anamorphosis is that less of the picture is wasted on letterbox mattes. DVD has a frame size designed for 1.33 display, so the video still has to be made to fit, but because it's only squeezed horizontally, 33% more pixels (25% of the total pixels in a video frame) are used to store active picture instead of black. Anamorphic video is best displayed on widescreen equipment, which stretches the video back out to its original width. Alternatively, many new 4:3 TV's can reduce the vertical scan area to restore the proper aspect ratio without losing resolution (an automatic trigger signal is sent to European TVs on SCART pin 8). Even though almost all computers have 4:3 monitors, they have higher resolution than TVs so they can display the full widescreen picture in a window (854x480 pixels or bigger for NTSC; 1024x576 or bigger for PAL).

Anamorphic video can be converted by the player for display on standard 4:3 TVs in letterbox or pan & scan form. If anamorphic video is shown unchanged on a standard 4:3 display, people will look tall and skinny as if they have been on a crash diet. The setup options of DVD players allow the viewer to indicate whether they have a 16:9 or 4:3 TV. In the case of a 4:3 TV, a second option lets the viewer indicate a preference for how the player will reformat anamorphic video. The two options are detailed below.

For automatic letterbox mode, the player generates black bars at the top and the bottom of the picture (60 lines each for NTSC, 72 for PAL). This leaves 3/4 of the height remaining, creating a shorter but wider rectangle (1.78:1). In order to fit this shorter rectangle, the anamorphic picture is squeezed vertically using a *letterbox filter* that combines every 4 lines into 3, reducing the vertical resolution from 480 scan lines to 360 (576 to 432 for PAL). If the video was already letterboxed to fit the 1.78 aspect, then the mattes generated by the player seamlessly extend the mattes in the video.) The vertical squeezing exactly compensates for the original horizontal squeezing so that the movie is shown in its full width. Some players have better letterbox filters than others, using weighted averaging to combine lines (scaling 4 lines into 3 or merging the boundary lines) rather than simply dropping one out of every four lines. Widescreen video can be letterboxed to 4:3 on expensive studio equipment before it's stored on the disc, or it can be stored in anamorphic form and letterboxed to 4:3 in the player. If you compare the two, the letterbox mattes will be identical but the picture quality of the studio version may be slightly better. (See [1.38](#) for more about letterboxing.)

For automatic pan & scan mode, the anamorphic video is unsqueezed to 16:9 and the sides are cropped off so that a portion of the image is shown at full height on a 4:3 screen by following a *center of interest* offset encoded in the video stream according to the preferences of those who transferred the film to video. The pan & scan "window" is 75% of the full width, which reduces the horizontal pixels from 720 to 540. The pan & scan window can only travel laterally. This does not duplicate a true pan & scan process in which the window can also travel up and down and zoom in and out. Auto pan & scan has three strikes against it: 1) it doesn't provide the same artistic control as studio pan & scan, 2) there is a loss of detail

when the picture is scaled up, and 3) equipment for recording picture shift information is not widely available. Therefore, no anamorphic movies have been released with auto pan & scan enabled, although some discs use the pan & scan feature in menus so that the same menu video can be used in both widescreen and 4:3 mode. In order to present a quality full-screen picture to the vast majority of TV viewers, yet still provide the best experience for widescreen owners, some DVD producers choose to put two versions on a single disc: 4:3 studio pan & scan and 16:9 anamorphic.

Playback of widescreen material can be restricted by the disc producer. Programs can be marked for the following display modes:

- 4:3 full frame
- 4:3 LB (for sending a letterbox expand signal to widescreen TV)
- 16:9 LB only (the player is not allowed to pan & scan on a 4:3 TV)
- 16:9 PS only (the player is not allowed to letterbox on a 4:3 TV)
- 16:9 LB or PS (the viewer can select pan & scan or letterbox on a 4:3 TV)

You can usually tell if a disc contains anamorphic video if the packaging says "enhanced for 16:9 widescreen" or something similar. If all it says is "widescreen," it may be letterboxed to 4:3, not 16:9. [Widescreen Review](#) has a list of anamorphic DVD titles.

Additional explanations of how anamorphic video works can be found at Greg Lovern's [What's an Anamorphic DVD?](#) page, Bill Hunt's [Ultimate Guide to Anamorphic Widescreen DVD](#), and Dan Ramer's [What the Heck Is Anamorphic?](#). More information can be found at the [Anamorphic Widescreen Support Page](#), the [Letterbox/Widescreen Advocacy Page](#), and [The American Widescreen Museum](#). You might also be interested in Guy Wright's [The Widescreen Scam](#). See [1.38](#) for further discussion of letterboxing.

Anamorphosis causes no problems with line doublers and other video scalers, which simply duplicate the scan lines before they are stretched out by the widescreen display.

For anamorphic video, the pixels are fatter. Different pixel aspect ratios (none of them square) are used for each aspect ratio and resolution. 720-pixel and 704-pixel sizes have the same aspect ratio because the first includes overscan. Note that conventional values of 1.0950 and 0.9157 are for height/width (and are tweaked to match scanning rates). The table below uses less-confusing width/height values ($y/x * h/w$).

	720x480	720x576		
	704x480	704x576	352x480	352x576
4:3	0.909	1.091	1.818	2.182
16:9	1.212	1.455	2.424	2.909

For gory details of video resolution and pixel aspect ratios see Jukka Aho's [Quick Guide to Digital Video Resolution and Aspect Ratio Conversions](#).

[3.6] What are the audio details?

DVD comes in two home-entertainment flavors: DVD-Video and DVD-Audio. Each supports high-definition multichannel audio, but DVD-Audio includes higher-quality PCM audio.

[3.6.1] Details of DVD-Audio and SACD

LPCM is mandatory in DVD-Audio discs, with up to 6 channels at sample rates of 48/96/192 kHz (also 44.1/88.2/176.4 kHz) and sample sizes of 16/20/24 bits. This allows theoretical frequency response of up to 96 kHz and dynamic range of up to 144 dB. Multichannel PCM is downmixable by the player, although at 192 and 176.4 kHz only two channels are available. Sampling rates and sizes can vary for different channels by using a predefined set of groups. The maximum data rate is 9.6 Mbps.

The DVD Forum's Working Group for audio (WG4) decided to include lossless compression, and on August 5, 1998 approved [Meridian's MLP](#) (Meridian Lossless Packing) scheme, licensed by Dolby. MLP removes redundancy from the signal to achieve a compression ratio of about 2:1 while allowing the PCM signal to be completely recreated by the MLP decoder that's required in all DVD-Audio players. MLP allows playing times of about 74 to 135 minutes of 6-channel 96-kHz/24-bit audio on a single layer (compared to 45 minutes without packing). Two-channel 192-kHz/24-bit playing times are about 120 to 140 minutes (compared to 67 minutes without packing).

Other audio formats of DVD-Video (Dolby Digital, MPEG audio, and DTS, described below) are optional on DVD-Audio discs, although Dolby Digital is required for audio content that has associated video. A subset of DVD-Video features (no angles, no seamless branching, etc.) is allowed. Most DVD-Audio players are also "universal" players that play DVD-Video discs as well.

DVD-Audio includes specialized downmixing features for PCM channels. Unlike DVD-Video, where the decoder determines how to mix from 6 channels down to 2, DVD-Audio includes coefficient tables to control mixdown and avoid volume buildup from channel aggregation. Up to 16 tables can be defined by each Audio Title Set (album), and each track can be identified with a table. Coefficients range from 0dB to 60dB. This feature goes by the horribly contrived name of SMART (system-managed audio resource technique). (Dolby Digital, supported in both DVD-Audio and DVD-Video, also includes downmixing information that can be set at encode time.)

DVD-Audio can provide up to 99 still images per track (at typical compression levels about 20 images fit into the 2 MB buffer in the player), with a set of limited transitions (cut in/out, fade in/out, dissolve, and wipe). Unlike DVD-Video, the user can move at will through the slides without interrupting the audio as it plays: this is called a browsable slideshow. On-screen displays can be used for synchronized lyrics and navigation menus. A special simplified navigation mode can be used on players without a video display.

Sony and Philips are promoting SACD, a competing DVD-based format using Direct Stream Digital (DSD) encoding with sampling rates of 2.8224 MHz. DSD is based on the pulse-density modulation (PDM) technique that uses single bits to represent the incremental rise or fall of the audio waveform. This supposedly improves quality by removing the brick wall filters required for PCM encoding. It also makes downsampling more accurate and efficient. DSD provides a frequency response from DC to over 100 kHz with a dynamic range of over 120 dB. DSD includes a lossless encoding technique that produces approximately 2:1 data reduction by predicting each sample and then run-length encoding the error signal. The maximum data rate is 2.8 Mbps.

SACD includes a physical watermarking feature, pit signal processing (PSP), which modulates the width of pits on the disc to store a digital watermark (data is stored in the pit length). The optical pickup must contain additional circuitry to read the PSP watermark, which is then compared to information on the disc to make sure it's legitimate. Because of the requirement for specialized watermark detection circuitry, protected SACD discs are not playable in standard DVD-ROM drives.

SACD includes text and still graphics, but no video. Sony says the format is aimed at audiophiles and is not intended to replace the audio CD format.

See [1.12](#) for more general info on DVD-Audio and SACD.

[3.6.2] Audio details of DVD-Video

The following details are for audio tracks in DVD-Video. Some DVD manufacturers such as Pioneer are developing audio-only players using the DVD-Video format. Some DVD-Video discs contain mostly audio with only still pictures.

A DVD-Video disc can have up to 8 audio tracks (streams) associated with each video track (or each video angle). Each audio track can be in one of three formats:

- Dolby Digital (AC-3): 1 to 5.1 channels
- MPEG-2 audio: 1 to 5.1 or 7.1 channels
- PCM: 1 to 8 channels.

Two additional optional formats are provided: DTS and SDDS. Both require the appropriate decoders and are not supported by all players.

The ".1" refers to a low-frequency effects (LFE) channel that connects to a subwoofer. This channel carries an emphasized bass audio signal.

Linear PCM is uncompressed (lossless) digital audio, the same format used on CDs and most studio masters. It can be sampled at 48 or 96 kHz with 16, 20, or 24 bits/sample. (Audio CD is limited to 44.1 kHz at 16 bits.) There can be from 1 to 8 channels. The maximum bit rate is 6.144 Mbps, which limits sample rates and bit sizes when there are 5 or more channels. It's generally felt that the 120 dB dynamic range of 20 bits combined with a frequency response of around 22,000 Hz from 48 kHz sampling is adequate for high-fidelity sound reproduction. However, additional bits and higher sampling rates are useful in audiophile applications, studio work, noise shaping, advanced digital processing, and three-dimensional sound field reproduction. DVD players are required to support all the variations of LPCM, but many subsample 96 kHz down to 48 kHz, and some may not use all 20 or 24 bits. The signal provided on the digital output for external digital-to-analog converters may be limited to less than 96 kHz and less than 24 bits.

Dolby Digital is multi-channel digital audio, using lossy AC-3 coding technology from PCM source with a sample rate of 48 kHz at up to 24 bits. The bitrate is 64 kbps to 448 kbps, with 384 or 448 being the normal rate for 5.1 channels and 192 being the typical rate for stereo (with or without surround encoding). (Most Dolby Digital decoders support up to 640 kbps, so non-standard discs with 640 kbps tracks play on many players.) The channel combinations are (front/surround): 1/0, 1+1/0 (dual mono), 2/0, 3/0, 2/1, 3/1, 2/2, and 3/2. The LFE channel is optional with all 8 combinations. For details see ATSC document A/52 <www.atsc.org/document.html>. Dolby Digital is the format used for audio tracks on almost all DVDs.

MPEG audio is multi-channel digital audio, using lossy compression from original PCM format with sample rate of 48 kHz at 16 or 20 bits. Both MPEG-1 and MPEG-2 formats are supported. The variable bit rate is 32 kbps to 912 kbps, with 384 being the normal average rate. MPEG-1 is limited to 384 kbps. Channel combinations are (front/surround): 1/0, 2/0, 2/1, 2/2, 3/0, 3/1, 3/2, and 5/2. The LFE channel is optional with all combinations. The 7.1 channel format adds left-center and right-center channels, but is rare for home use. MPEG-2 surround channels are in an extension stream matrixed onto the MPEG-1 stereo channels, which makes MPEG-2 audio backwards compatible with MPEG-1 hardware (an MPEG-1 system will only see the two stereo channels.) MPEG Layer 3 (MP3) and MPEG-2 AAC (also known as NBC or unmatrix) are not supported by the DVD-Video standard. MPEG audio is not used much on DVDs, although some inexpensive DVD recording software programs use MPEG audio, even on NTSC discs, which goes against the DVD standard and is not supported by all NTSC players.

DTS (Digital Theater Systems) Digital Surround is an optional multi-channel digital audio format, using lossy compression from PCM at 48 kHz at up to 24 bits. The data rate is from 64 kbps to 1536 kbps, with typical rates of 754.5 and 1509.25 for 5.1 channels and 377 or 754 for 2 channels. (The DTS Coherent Acoustics format supports up to 4096 kbps variable data rate for lossless compression, but this isn't supported by DVD. DVD also does not allow DTS sampling rates other than 48 kHz.). Channel combinations are (front/surround): 1/0, 2/0, 3/0, 2/1, 2/2, 3/2. The LFE channel is optional with all combinations. DTS ES support 6.1 channels in two ways: 1) a Dolby Surround EX compatible matrixed rear center channel, 2) a discrete 7th channel. DTS also has a 7.1-channel mode (8 discrete channels), but no DVDs have used it yet. The 7-channel and 8-channel modes require a new decoder. The DVD standard includes an audio stream format reserved for DTS, but many older players ignore it. The DTS format used on DVDs is different from the one used in theaters ([Audio Processing Technology's](#) apt-X, an ADPCM coder, not a psychoacoustic coder). All DVD players can play DTS audio CDs, since the standard PCM stream holds the DTS code. See [1.32](#) for general DTS information. For more info visit <www.dtstech.com> and read Adam Barratt's [article](#).

SDDS (Sony Dynamic Digital Sound) is an optional multi-channel (5.1 or 7.1) digital audio format, compressed from PCM at 48 kHz. The data rate can go up to 1280 kbps. SDDS is a theatrical film soundtrack format based on the ATRAC compression format that is also used by Minidisc. Sony has not announced any plans to support SDDS on DVD.

THX (Tomlinson Holman Experiment) is not an audio format. It's a certification and quality control program that applies to sound systems and acoustics in theaters, home equipment, and digital mastering processes. The LucasFilm THX Digital Mastering program uses a patented process to track video quality through the multiple video generations needed to make a final format disc or tape, setup of video monitors to ensure that the filmmaker is seeing a precise rendition of what is on tape before approval of the master, and other steps along the way. THX-certified "4.0" amplifiers enhance Dolby Pro Logic in the following ways: a crossover that sends bass from front channels to subwoofer; re-equalization on front channels (to compensate for high-frequency boost in theater mix designed for speakers behind the screen); timbre matching on rear channels; decorrelation of rear channels; a bass curve that emphasizes low frequencies. THX-certified "5.1" amplifiers enhance Dolby Digital and improve on 4.0 in the following ways: rear speakers are full range, so the crossover sends bass from both front and rear to the subwoofer; decorrelation is turned on automatically when rear channels have the same audio, but not during split-surround effects, which don't need to be decorrelated. More info at [Home THX Program Overview](#).

Discs containing 525/60 (NTSC) video must use PCM or Dolby Digital on at least one track. Discs containing 625/50 (PAL/SECAM) video must use PCM or MPEG audio or Dolby Digital on at least one track. Additional tracks may be in any format. A few first-generation players, such as those made by Matsushita, can't output MPEG-2 audio to external decoders.

The original DVD-Video spec required either MPEG audio or PCM on 625/50 (PAL) discs. There was a brief scuffle led by Philips when early discs came out with only two-channel MPEG and multichannel Dolby Digital, but the DVD Forum clarified in May of 1997 that only stereo MPEG audio was mandatory for 625/50 discs. In December 1997 the lack of MPEG-2 encoders (and decoders) was a big enough problem

that the spec was revised to allow Dolby Digital audio tracks to be used on 625/50 discs without MPEG audio tracks.

Because of the 4% speedup from 24 fps film to 25 fps PAL display, the audio must be adjusted to match before it is encoded. Unless the audio is digitally processed to shift the pitch back to normal it will be slightly high (about half a semitone).

For stereo output (analog or digital), all players have a built-in 2-channel Dolby Digital decoder that *downmixes* from 5.1 channels (if present on the disc) to Dolby Surround stereo. That is, 5 channels are phase matrixed into 2 channels to be decoded to 4 channels by a Dolby Pro Logic processor or 5 channels by a Pro Logic II processor. PAL players also have an MPEG or MPEG-2 audio decoder. Both Dolby Digital and MPEG-2 support 2-channel Dolby Surround as the source in cases where the disc producer can't or doesn't want to remix the original onto discrete channels. This means that a DVD labeled as having Dolby Digital sound may only use the L/R channels for surround or "plain" stereo. Even movies with old monophonic soundtracks may use Dolby Digital with only 1 or 2 channels. Some players can optionally downmix to non-surround stereo. If surround audio is important to you, you will hear significantly better results from multichannel discs if you have a Dolby Digital system.

The new Dolby Digital Surround EX format (DD-EX), which adds a rear center channel, is compatible with DVD discs and players, and with existing Dolby Digital decoders. The new DTS-ES Matrix format, which likewise adds a rear center channel, works with existing DTS decoders and with DTS-compatible DVD players. However, for full use of either new format you need a new decoder to extract the rear center channel, which is phase matrixed into the two standard rear channels in the same way Dolby Surround is matrixed into standard stereo channels. Without a new decoder you'll get the same 5.1-channel audio you get now. Because the additional rear channel isn't a full-bandwidth discrete channel, it's appropriate to call the new formats "5.2-channel" digital surround. There is also DTS-ES Discrete, which adds a full-bandwidth discrete rear center channel in an extension stream which is used by DTS ES Discrete decoders but ignored by older DTS decoders. DTS-ES decoders include DTS Neo:6, which is not an encoding format but a matrix decoding process that provides 5 or 6 channels.

The Dolby Digital downmix process does not usually include the LFE channel and may compress the dynamic range in order to improve dialog audibility and keep the sound from becoming "muddy" on average home audio systems. This can result in reduced sound quality on high-end audio systems. The downmix is auditioned when the disc is prepared, and if the result is not acceptable the audio may be tweaked or a separate L/R Dolby Surround track may be added. Experience has shown that minor tweaking is sometimes required to make the dialog more audible within the limited dynamic range of a home stereo system. Some disc producers include a separately mixed stereo track rather than fiddle with the surround mix.

The Dolby Digital *dynamic range compression* (DRC) feature, often called *midnight mode*, reduces the difference between loud and soft sounds so that you can turn the volume down to avoid disturbing others yet still hear the detail of quiet passages. Some players have the option to turn off DRC.

Dolby Digital also includes a feature called *dialog normalization* (DN), which should more accurately be called volume standardization. DN is designed to keep the sound level the same when switching between different sources. This will become more important as additional Dolby Digital sources (digital satellite, DTV, etc) become common. Each Dolby Digital track contains loudness information so that the receiver can automatically adjust the volume, turning it down, for example, on a loud commercial. (Of course the commercial makers can cheat and set an artificially low DN level, causing your receiver to turn up the volume during the commercial.) Turning DN on or off on your receiver has no effect on dynamic range or sound quality; its effect is no different than turning the volume control up or down.

All five DVD-Video audio formats support karaoke mode, which has two channels for stereo (L and R) plus an optional guide melody channel (M) and two optional vocal channels (V1 and V2).

A DVD-5 with only one surround stereo audio stream (at 192 kbps) can hold over 55 hours of audio. A DVD-18 can hold over 200 hours.

For more information about multichannel surround sound, see Bobby Owsinski's FAQ at <www.surroundassociates.com/fqmain.html>.

[3.6.3] Can you explain this Dolby Digital, Dolby Surround, Dolby Pro Logic, DTS stuff in plain English?

Almost every DVD contains audio in the *Dolby Digital (AC-3)* format. *DTS* is an optional audio format that can be added to a disc in addition to Dolby Digital audio. Dolby Digital and DTS can store mono, stereo, and multichannel audio (usually 5.1 channels).

Every DVD player in the world has an internal Dolby Digital decoder. The built-in 2-channel decoder turns Dolby Digital into stereo audio, which can be fed to almost any type of audio equipment (receiver, TV, boombox, etc.) as a standard analog stereo signal using a pair of stereo audio cables or as a digital PCM audio signal using a coax or optical cable. See [3.2](#) for more information.

A standard audio mixing technique, called *Dolby Surround*, "piggybacks" a rear channel and a center channel onto a 2-channel signal. A Dolby Surround signal can be played on any stereo system (or even a mono system), in which case the rear- and center-channel sounds remain mixed in with the left and right channels. When a Dolby Surround signal is played on a multichannel audio system that knows how to handle it, the extra channels are extracted to feed center speakers and rear speakers. The original technique of decoding Dolby Surround, called simply *Dolby Surround*, extracts only the rear channel. The improved decoding technique, *Dolby Pro Logic*, also extracts the center channel. A brand new decoding technology, *Dolby Pro Logic II*, extracts both the center channel and the rear channel and also processes the signals to create more of a 3D audio environment. Dolby Surround is independent of the storage or transmission format. In other words, a 2-channel Dolby Surround signal can be analog audio, broadcast TV audio, digital PCM audio, Dolby Digital, DTS, MP3, audio on a VHS tape, etc.

Unlike Dolby Surround, Dolby Digital encodes each channel independently. Dolby Digital can carry up to 5 channels (left, center, right, left surround, right surround) plus an omnidirectional low-frequency channel. The built-in, 2-channel Dolby Digital decoder in every DVD player handles multichannel audio by *downmixing* it to two channels using Dolby Surround (see [3.6.2](#)). This allows the analog stereo outputs to be connected to just about anything, including TVs and receivers with Dolby Pro Logic capability. Most DVD players also output the downmixed 2-channel Dolby Surround signal in digital PCM format, which can be connected to a digital audio receiver, most of which do Dolby Pro Logic decoding.

Most DVD players also output the "raw" Dolby Digital signal for connection to a receiver with a built-in Dolby Digital decoder. Some DVD players have built-in multichannel decoders to provide 6 (or 7) analog audio outputs to feed a receiver or amplifier with multichannel analog inputs. See [3.1](#) for more info.

DTS is handled differently. Many DVD players have a *DTS Digital Out* feature (also called DTS pass-through), which sends the raw DTS signal to an external receiver with a DTS decoder. A few players have a built-in 2-channel DTS decoder that downmixes to Dolby Surround, just like a 2-channel Dolby Digital decoder. Some players have a built-in multichannel DTS decoder with 6 (or 7) analog outputs. Some DVD players don't recognize DTS tracks at all (see [1.32](#)).

If you have a POS (plain old stereo), a Dolby Surround receiver, or a Dolby Pro Logic receiver, you don't need anything special in the DVD player. Any model will connect to your system. If you have a Dolby Digital receiver, then you need a player with Dolby Digital out (all but the cheapest players have this). If your receiver can also do DTS, you should get a player with DTS Digital Out. The only reason to get a player with 6-channel Dolby Digital or DTS decoder output is if you want use multichannel analog connections to the receiver (see the component analog section of [3.2](#)).

[3.6.4] Why is the audio level from my DVD player so low?

Many people complain that the audio level from DVD players is too low. In truth the audio level is too high on everything else. Movie soundtracks are extremely dynamic, ranging from near silence to intense explosions. In order to support an increased dynamic range and hit peaks (near the 2V RMS limit) without distortion, the average sound volume must be lower. This is why the line level from DVD players is lower than from almost all other sources. So far, unlike on CDs and LDs, the level is much more consistent between discs. If the change in volume when switching between DVD and other audio sources is annoying, you may be able to adjust the output signal level on some players or the input signal level on some receivers, but other than that, there's not much you can do.

[3.6.5] Why is the dialog hard to hear?

Dialog (people speaking) is usually mixed into the center channel, with music, effects, and ambience mixed into other channels. If your audio system isn't hooked up correctly or doesn't work properly, the center channel might not be properly reproduced. If you have a system with only two speakers, make sure it is connected to the stereo outputs, not the multichannel outputs (see [3.2](#)).

In some cases the movie sound was not mixed well in the studio, making the dialog hard to hear. In this case there's not much you can do other than curse the sound engineer who thought sound effects were more important than understanding what people are saying.

Try turning on dynamic range compression (see [3.6.2](#)) or check the disc to see if there is a separate 2-channel soundtrack mix.

[3.7] How do the interactive features work?

DVD-Video players (and software DVD-Video navigators for computers) support a command set that provides rudimentary interactivity. The main feature is menus, which are present on almost all discs to allow content selection and feature control. Each menu has a still or motion background and up to 36 highlightable, rectangular "buttons" (only 12 if widescreen, letterbox, and pan & scan modes are used). Remote control units have up/down/left/right arrow keys for selecting onscreen buttons, along with numeric keys, a select (enter) key, a menu key, a top menu (title) key, and a return key. Additional remote functions may include freeze, step, slow, fast, scan, next, previous, audio select, subtitle select, camera angle select, play mode select, search to program, search to part of title (chapter), search to time, and search to camera angle. Any of these features can be disabled by the producer of the disc, an act which is called *user operation control* (UOP). It's commonly used to lock you into the copyright warning or movie previews at the beginning of the disc, or to keep you from changing audio or subtitle tracks during the movie.

Additional features of the command set include simple math (add, subtract, multiply, divide, modulo, random), bitwise and, bitwise or, bitwise xor, plus comparisons (equal, greater than, etc.), and register loading, moving, and swapping. There are 24 system registers for information such as language code, audio and subpicture settings, and parental level. There are 16 general registers for command use. A countdown timer is also provided. Commands can branch or jump to other commands. Commands can also control player settings, jump to different parts of the disc, and control presentation of audio, video, subpicture, camera angles, and so on. The command set enables relatively sophisticated discs, such as games or interactive educational programs.

DVD-V content is broken into *titles* (movies or albums), and *parts of titles* (chapters or songs). Titles are made up of *cells* grouped into *programs* and linked together by one or more *program chains* (PGC). A PGC can be one of three types: sequential play, random play (may repeat), or shuffle play (random order but no repeats). Individual cells may be used by more than one PGC, which is how parental management and seamless branching are accomplished: different PGCs define different sequences through mostly the same material.

Additional material for camera angles and seamless branching is interleaved together in small chunks. The player jumps from chunk to chunk, skipping over unused angles or branches, to stitch together the seamless video. Since angles are stored separately, they have no direct effect on the bitrate but they do affect the playing time. Adding 1 camera angle for a program roughly doubles the amount of space needed (and cuts the playing time in half). Examples of branching (seamless and non-seamless) include *Kalifornia*, *Dark Star*, *Stargate SE*, and *The Abyss*.

[3.8] What is the difference between interlaced and progressive video?

There are basically two ways to display video: *interlaced scan* or *progressive scan*. Progressive scan, used in computer monitors and digital televisions, displays all the horizontal lines of a picture at one time as a single *frame*. Interlaced scan, used in standard television formats (NTSC, PAL, and SECAM), displays only half of the horizontal lines at a time (the first *field*, containing the odd-numbered lines, is displayed, followed by the second field, containing the even-numbered lines). Interlacing relies on phosphor persistence of the TV tube to blend the fields together over a fraction of a second into a seemingly single picture. The advantage of interlaced video is that a high refresh rate (50 or 60 Hz) can be achieved with only half the bandwidth. The disadvantage is that the horizontal resolution is essentially cut in half, and the video is often filtered to avoid flicker (interfield twitter) and other artifacts.

It may help to understand the difference by considering how the source images are captured. A film camera captures full frames in intervals that are 1/24th of a second long, whereas a video camera alternately scans fields of odd and even lines in 1/60th of a second intervals, resulting in interlaced frames that are 1/30th of a second long. (Unlike projected film, where the entire frame is shown in an instant, many progressive-scan displays trace a series of lines from top to bottom, but the end result is about the same.)

DVD is specifically designed to be displayed on interlaced-scan displays, which represent 99.9 percent of the more than one billion TVs worldwide. However, most DVD content comes from film, which is inherently progressive. To make film content work in interlaced form, the video from each film frame is split into two video fields —240 lines in one field, and 240 lines in the other— and encoded as separate fields in the MPEG-2 stream. A complication is that film runs at 24 frames per second, whereas TV runs at 30 frames (60 fields) per second for NTSC, or 25 frames (50 fields) per second for PAL and SECAM. For PAL/SECAM display, the simple solution is to show the film frames at 25 per second, which is a 4 percent speed increase, and to speed up the audio to match. For NTSC display, the solution is to spread 24 frames across 60 fields by alternating the display of the first film frame for 2 video fields and the next film frame for 3 video fields. This is called *2-3 pulldown*. The sequence works as shown below, where A through D represent film frames; A1, A2, B1, and so on represent the separation of each film frame into two video fields; and 1 through 5 represent the final video frames.

Film frames:		A		B		C		D								
Video fields:		A1	A2		B1	B2		B1	C2		C1	D2		D1	D2	
Video frames:		1		2		3		4		5						

For MPEG-2 encoding, repeated fields (B1 and D2) are not actually stored twice. Instead, a flag is set to tell the decoder to repeat the field. (The inverted order of C2 and C1, and D2 and D1 are because of the requirement that top and bottom fields alternate. Since the fields are from the same film frame, the order doesn't matter.) MPEG-2 also has a flag to indicate when a frame is progressive (that the two fields come from the same instant in time). For film content, the `progressive_frame` flag should be true for every frame. See [3.4](#) for more MPEG-2 details.

As you can see, there are a couple of problems inherent in 2-3 pulldown: 1) some film frames are shown for a longer period of time than others, causing *judder*, or jerkiness, that shows up especially in smooth pans; 2) if you freeze the video on the third or fourth video frame when there is motion in the picture you will see two separate images combined in a flickering mess. Most DVD players avoid the second problem by only pausing on coherent frames or by only showing one field, although some allow you to freeze on flicker-frames. (This is what the frame/field still option in the player's setup menu refers to.)

Most DVD players are hooked up to interlaced TVs, so there's not much that can be done about artifacts from film conversion. However, see [1.40](#) for information about progressive DVD players.

For more on progressive video and DVD, see [part 5](#) and [player ratings](#) in the excellent [DVD Benchmark](#) series at Secrets of Home Theater and High Fidelity, and Dan Ramer's [What The Heck Is 3:2 Pulldown?](#) at DVDFile.com.

Note: "2-3 pulldown" is the same term as "3:2 pulldown," but this FAQ uses the "2-3" notation to indicate that it's a sequence, not a ratio, and that in practice 2 video fields are usually created from the first film frame.

[3.9] What is edge enhancement?

When films are transferred to video in preparation for DVD encoding, they are commonly run through digital processes that attempt to clean up the picture. These processes include digital video noise reduction (DVNR) and image enhancement. Enhancement increases contrast (similar to the effect of the "sharpen" or "unsharp mask" filters in PhotoShop), but can tend to overdo areas of transition between light and dark or different colors, causing a "chiseled" look or a *ringing* effect like the haloes you see around streetlights when driving in the rain.

Video noise reduction is a good thing, when done well, since it can remove scratches, spots, and other defects from the original film. Enhancement, which is rarely done well, is a bad thing. The video may look sharper and clearer to the casual observer, but fine tonal details of the original picture are altered and lost.

Note that ringing can also be caused by the player and by the TV. Scan velocity modulation (SVM), for example, causes ringing.

[3.10] Does DVD work with barcodes?

If your humble FAQ author and other long-time developers of laserdisc had prevailed, all DVD players would support barcodes. This would have made for really cool printed supplements and educational material that could jump to any part of a disc with a swipe of a barcode wand. But the rejection of our recommendations after an all-star meeting in August 1995 is another story for another day.

So the answer is "mostly no." A few industrial players, the Pioneer LD-V7200, Pioneer [LD-V7400](#), and Philips [ProDVD-170](#) support barcodes, including compatibility with the LaserBarCode standard. The DVD must be authored with one_sequential_PGC titles in order for timecode search to work. More info can be found in the Pioneer [technical manuals](#).

[3.11] What is BCA or NBCA?

BCA stands for burst cutting area, a zone near the hub of a DVD reserved for a barcode that can be etched into the disc by a high-powered (YAG) laser. NBCA (narrow burst cutting area) is a thinner-diameter variation used on recordable discs to avoid impinging on the lead-in. Because barcode cutting is independent of the stamping process, each disc can have unique data recorded in the BCA, such as a serialized ID. DVD readers can use the laser pickup head to read the BCA.

The BCA is used by CPRM (see [1.11](#)) and Divx (see [2.10](#)) to uniquely identify each disc.

[3.12] How long do DVDs last?

DVDs are read by a laser, so they never wear out from being played since nothing touches the disc. Pressed discs (the kind that movies come on) will probably last longer than you will, anywhere from 50 to 300 years.

Expected longevity of dye-based DVD-R and DVD+R discs is anywhere from 20 to 250 years, about as long as CD-R discs. Some dye formulations (such as phthalocyanine and azo) are more stable and last longer, 100 years or more, compared to 20 or 30 years for less stable dyes.

The phase-change erasable formats (DVD-RAM, DVD-RW, and DVD+RW) have an expected lifetime of 25 to 100 years.

In all cases, longevity can be reduced by poor quality. Poor quality pressed DVDs may deteriorate within a few years, and cheap recordable DVDs may produce errors when recording or may become unreadable after a while. (See [1.24](#).)

For more info see [Lifetime of KODAK CD-R Ultima Media](#) and [<www.ee.washington.edu/conselec/CE/kuhn/otherformats/95x9.htm>](#).

For comparison, magnetic media (tapes and disks) last 10 to 30 years; high-quality, acid-neutral paper can last 100 years or longer; and archival-quality microfilm is projected to last 300 years or more. Note that computer storage media often becomes technically obsolete within 20 to 30 years, long before it physically deteriorates. In other words, before the media becomes unviable it may become difficult or impossible to find equipment that can read it.

[3.13] What about the HD-DVD and blue laser formats?

Next-generation DVD (often called HD DVD, where HD stands for both high-density and high-definition) was under development before DVD came out. It began to emerge in 2003 (see [2.12](#) for general info). Some high-definition versions of DVD use the original DVD physical format but depend on new video encoding technology such as H.264 and VC-1 to fit high-definition video in the space that used to hold only standard-definition video. High-density formats use blue or violet lasers to read smaller pits, increasing data capacity to around 15 to 30 GB per layer. High-density formats use high-definition MPEG-2 video (for compatibility with ATSC and DVB HD broadcasts, see [2.9](#)) and also use advanced encoding formats, supporting 720p and 1080p video.

As of mid 2004 there are five contenders for HD-DVD, with the possibility of others. Here's a summary (more detail in the following sections):

Format	Backers	Data depth	Laser	Video	Audio	Capacity (single layer/dual layer)	Data rate
WMV HD	Microsoft	0.6 mm	Red (650 nm)	WMV9	WMA9	4.7G / 8.5G (standard DVD)	22 Mbps
HD-DVD	DVD Forum	0.6 mm	Blue (405 nm)	MPEG-2 SD/HD, H.264, VC-1	PCM, MLP, Dolby Digital +, DTS HD	15G / 30G (ROM), 20G / 40G (recordable)	36 Mbps
Blu-ray (BD)	Blu-Ray Disc Association	0.1 mm	Blue (405 nm)	MPEG-2 HD, H.264, VC-1	PCM, Dolby Digital, DTS	27G / 50G	36 Mbps

			nm)				
EVD	eWorld (Govt. of China)	0.6 mm	Red (650 nm)	HD MPEG-2 (later AVS)	ExAC	na / 8.5G (ROM)	22 Mbps
FVD	AOSRA/ITRI (Taiwan)	0.6 mm	Red (650 nm)	WMV9 (1280x720)	WMA9	6G / 11/G	25.05 Mbps

* VC-1 is the SMPTE standard based on Microsoft's Windows Media Series 9.

HD discs will not play on existing players. Even red-laser discs, which the player may be able to physically read, require new circuitry to decode and display the high-def video. Red-laser discs can play on DVD PCs with the right software (for example, HD versions of DVDs using Microsoft HD-WMV were available in 2003). Blue-laser discs require new optical assemblies and controllers. HD players will undoubtedly read existing DVDs, so your collection will not become obsolete when you buy a new player.

None of the HD formats will be used for movies until 2005 or 2006.

WMV HD

[WMV HD](#) isn't really a new format. Microsoft's high-definition video format comes on standard dual-layer DVDs and plays in Windows PCs with enough power (2.4 to 3 GHz). As of mid 2004 about 20 titles were available in WMV HD format, usually with both a standard DVD and a WMV HD DVD in the package. This is an interim format that will probably disappear after HD-DVD and BD come out, but in the meantime it's the best option for publishing high-definition video on DVD.

HD-DVD (AOD)

The [DVD Forum](#)'s next-generation format, once called *Advanced Optical Disc* (AOD), currently being called HD-DVD, but soon to have a new name. AOD is a modification of the existing DVD physical format to enable about 15 GB per layer using a blue-ultraviolet readout laser. The same 0.6-mm data depth is used. AOD is designed to improve data capacity while theoretically being able to use existing replication equipment. It is primarily supported by Toshiba and NEC.

For a while there was a proposal being called HD-DVD-9, which put high-definition video on existing dual-layer DVD-9 discs. It has been combined with HD-DVD (AOD) in the sense that the application format is being designed to work on both current red-laser DVDs as well as future blu-laser DVDs. It's essentially a compatible-but-cheaper-to-replicate companion to blue-laser HD-DVD. A 2-hour movie can fit on a DVD-9 at data rates of 6 to 7 Mbps. Given advances in video compression technology, it should be possible to get high-definition quality of at least 720p24 at these data rates (720 lines of progressive video at 24 frames/second). Shorter movies could be encoded in 1080p24 format.

Blu-ray Disc (BD)

[Blu-ray](#) is a new high-density physical format that will hold 23 to 30 GB per layer using a blue-ultraviolet laser and a 0.1-mm data depth. Because of the 0.1-mm cover layer it will require significant changes to production equipment. Blu-ray is initially intended for home recording, professional recording, and data recording. Mass-market distribution of pre-recorded movies will come later, after the read-only format, called BD-ROM, is developed and the details of video, audio, interactivity, and copy protection are hammered out. Blue-ray backers are Dell, Hitachi, HP, LG, Panasonic, Philips, Pioneer, Mitsubishi, Samsung, Sharp, Sony, and Thomson. Sony released the first BD recorder in Japan in April 2003.

Technical details: up to 30 GB per layer using 0.1-mm recording depth (to reduce aberration from disc tilt), 405-nm blue-violet semiconductor with 0.85 NA (numerical aperture) lens design to provide 0.32 μ m track pitch (half that of DVD) and as small as 0.138 μ m pit length. Variations include 23.3 GB capacity with 0.160- μ m minimum pit length (used by Sony's *Professional Disc* system) and 25 GB capacity with 0.149- μ m minimum pit length. The physical discs uses phase-change groove recording on a 12-cm diameter, 1.2-mm thick disc, similar to DVD-RW and DVD+RW. 36 Mbps data transfer rate. Recording capacity on a single layer is about 2 hours of HD video (at 28 Mbps) or about 10 hours of standard-definition video (at 4.5 Mbps). Cartridge size is 129 x 131 x 7 mm. Plans are to produce dual-layer recordable discs, holding about 50 GB per side, but such discs will take a few additional years to appear.

EVD

A government-backed consortium of companies in China, called eWorld, has developed a domestic version of DVD called EVD (Enhanced Versatile Disc). EVD is an aggressive program to standardize on technology developed within China, but in order to realistically release products, the early phases borrow from existing standards. EVD players released in December 2003 used standard red lasers and MPEG HD video, along with China's own ExAC audio format. The plan was to switch to a Chinese video format, AVS, in 2004. Future versions will use multilevel red laser and multilevel blue laser recording, where the pit depth is varied to achieve higher density.

EVD was ostensibly developed to reduce reliance on and cost of non-Chinese patents, but ironically all EVD players play DVD, so nothing has changed in the short term.

FVD

The Advanced Optical Storage Research Alliance (AOSRA), formed by Taiwan's [Industrial Technology Research Institute](#) (ITRI) has developed its own tweaked red-laser format called Forward Versatile Disc (FVD). The track pitch has been reduced from 0.74μm to 0.64μm to increase capacity to 5.4 GB, with the potential to hit 6 GB (9.8 to 11 GB with dual layers). Microsoft's WM9 is used for video and audio encoding. So far even Taiwanese companies seem to be paying more attention to BD than FVD. AOSRA has also developed its own variations of 0.6-mm and 0.1-mm blue-laser formats, which could be used for future versions of FVD.

[4] DVD and computers

[4.1] Can I play DVD movies on my computer?

Yes, if your computer has the right stuff. Almost all Windows and Mac OS computers with DVD drives come with software to play DVDs.

The computer operating system or playback software must support regional codes and be licensed to descramble copy-protected movies. If the computer has TV video out, it must support Macrovision in order to play copy-protected movies. You may also need software that can read the UDF file system format used by DVDs. You don't need special drivers for Windows or Mac OS, since the existing CD-ROM drivers work fine with DVD-ROM drives. In addition to a DVD-ROM drive you must have software (or extra hardware) that knows how to play the DVD-Video format and decode MPEG-2 video and Dolby Digital or MPEG-2 audio. Good-quality software-only playback requires a 350-MHz Pentium II or a Mac G4. Almost all new computers with DVD-ROM drives use software decoding instead of hardware decoding. Hardware upgrade kits can be purchased for older computers (usually minimum 133 MHz Pentium or G3), starting at \$150.

Mac OS X 10.0 (Cheetah) had no support for DVD playback when released in March 2001, and also did not support Apple's DVD authoring applications (iDVD and DVD Studio Pro). (More info at [CNET](#).) Support for DVD playback was added to version 10.1 (Puma).

If you're having problems playing movies on your computer, see section [4.6](#).

Certain MPEG decoding tasks such as motion compensation, IDCT (inverse discrete cosine transform), IVLC (inverse variable length coding), and even subpicture decoding can be performed by special circuitry on a video graphics chip, improving the performance of software decoders. This is called *hardware decode acceleration*, *hardware motion comp*, or *hardware assist*. Some card makers also call it hardware decode, even though they don't do all the decoding in hardware. All modern graphics cards also provide hardware colorspace conversion (YCbCr to RGB) and videoport overlay (some graphics card makers make a big deal about this even though all their competitors' cards have the same feature).

Microsoft Windows 98, 2000, Me, and XP include [DirectShow](#), which provides standardized support for DVD-Video and MPEG-2 playback. DirectShow can also be installed in Windows 95 (it's available for [download](#)). DirectShow creates a framework for DVD applications, but a third-party hardware or software decoder is required (see below). Windows NT 4.0 supports DVD-ROM drives for data, but has very little support for playing DVD-Video discs. Margi DVD-To-Go, Sigma Designs Hollywood Plus, and the related Creative Labs Dxr3 are among the few hardware decoders that work in NT 4.0. InterVideo WinDVD software works in NT 4.0 (National Semiconductor DVD Express and MGI SoftDVD Max also work in NT 4.0, but they aren't available retail.) Windows 98 and newer can read UDF discs. Version 6.1 of [Windows Media Player](#) enabled scriptable DVD playback in an HTML page (see [4.9](#) for more on DVD playback control). Version 7 of Windows Media Player dropped all DVD support. Version 8 of Windows Media Player

added a user interface for DVD playback, but no scripting. [Roxio](#) provides a free filesystem driver, *UDF Reader*, for Windows 95/98/NT. [Software Architects](#) sells *Read DVD* for Windows 95.

Apple [QuickTime](#) 6 is partially ready for DVD-Video and MPEG-2 but does not yet have full decoding or DVD-Video playback support in place. Mac OS 8.1 or newer can read UDF discs. [Roxio](#) provides a free utility, *UDF Volume Access*, that enables Mac OS 7.6 and newer to read UDF discs. [Software Architects](#) sells UDF reading software for Mac OS called *DVD-RAM TuneUp*. [Intech](#)'s CD/DVD SpeedTools software allows most any DVD drive to be used with a Mac.

Note: The *QuickTime MPEG Extension for Mac OS* is for MPEG-1 only and does not play MPEG-2 DVD-Video.

DVD player applications (using either software or hardware decoding) are virtual DVD players. They support DVD-Video features (menus, subpictures, etc.) and emulate the functionality of a DVD-Video player remote control. Many player applications include additional features such as bookmarks, chapter lists, and subtitle language lists.

Microsoft Windows includes a DVD software player, but does not include the necessary decoder. You must have a third-party software or hardware decoder in order to play a DVD. Most PCs that come with a DVD drive include a decoder, or you can purchase one. See [4.11](#) and [4.12](#) for more info.

Software decoders and DVD player applications for Microsoft Windows PCs:

- [ATI](#): special version of CineMaster software for certain ATI graphics cards
- [ASUS](#): *ASUSDVD* (custom version of InterVideo WinDVD software or CyberLink PowerDVD software)
- [KiSS](#): *CoolDVD* (DirectShow [Windows 98/Me/2000/XP])
- [Creative Technology](#): *SoftPC-DVD*
- [CyberLink](#): *PowerDVD* (DirectShow [Windows 98/Me/2000/XP]; NT 4.0; available for [purchase](#))
- [ELSA](#): *ELSAMovie*, German only
- [InterVideo](#): *WinDVD* (DirectShow [Windows 98/Me/2000/XP]; NT 4.0; available for [purchase](#))
- [Matrox](#): special version of CineMaster software for certain Matrox graphics cards
- [National Semiconductor](#): *DVD Express* (DirectShow [Windows 98/Me/2000/XP]; OEM only)
- NEC (NEC PCs only)
- *Odyssey DVD Player* is no longer available
- [Orion Studios](#): *DirectDVD* (DirectShow, downloadable trial; note unsatisfactory rating at [BBB](#))
- [Sonic](#) (formerly Ravisent, formerly Quadrant International): *CinePlayer* (DirectShow [Windows 98/Me/2000/XP]; available for [purchase](#))
- [Varo Vision](#): *VaroDVD*
- *Xing DVDPlayer* is no longer available since the company was purchased by Real Networks

Software decoders need at least a 350 MHz Pentium II and a DVD-ROM drive with bus mastering DMA to play without dropped frames. Anything slower than a 400 MHz Pentium III will benefit quite a bit from hardware decode acceleration in the graphics card. An AGP graphics card (rather than PCI) also improves the performance of software decoders.

Hardware decoder cards and DVD-ROM upgrade kits for Microsoft Windows PCs are pretty much a thing of the past. Hardware decoders use *video overlay* to insert the video into the computer display. Some use analog overlay, which takes the analog VGA signal output from the graphics card and keys in the video, while others use video port extension (VPE), a direct digital connection to the graphics adapter via a cable inside the computer. Analog overlay may degrade the quality of the VGA signal. See [4.4](#) for more overlay info.

Many Macintosh models come standard with DVD-ROM, DVD-RAM, or DVD-RW drives. The included Apple software DVD player uses hardware acceleration in the ATI graphics card. The still-unreleased QuickTime MPEG-2 decoder may use the Velocity Engine (AltiVec) portion of the PowerPC (G4) chip for video and audio decoding. DVD-ROM upgrade kits and decoder cards for Macintoshes were made by [E4 \(Elecede\)](#) (*Cool DVD*, C-Cube chip) [E4 has gone out of business], [EZQuest](#) (*BOA Mac DVD*), [Fantom Drives](#) (*DVD Home Theater* kit: DVD-ROM or DVD-RAM drive with Wired MPEG-2 card), and [Wired](#) (*Wired 4DVD*, Sigma EM8300 chip [same card as Hollywood plus]; *MasonX* [can't play encrypted movies]; *DVD-To-Go* [out of production]; Wired was acquired by [Media100](#) but later reconstituted). There's a beta version of a shareware DVD [software player](#) that can play unencrypted movies.

The [Sigma Designs NetStream 2000](#) DVD decoder card supports Linux DVD playback. InterVideo and CyberLink have also announced DVD player applications for Linux, although the CyberLink player is only available to OEMs. In addition, there are free software players for Linux, Unix, BeOS, and other operating systems: [MPlayer](#), [OMS](#) (LiViD), [VideoLan](#), and [Xine](#).

Computers have the potential to produce better video than set-top DVD-Video players by using progressive display and higher scan rates, but many PC systems don't look as good as a home player hooked up to a quality TV.

If you want to hook a DVD computer to a TV, the decoder card or the VGA card must have a TV output (composite video or s-video). Video quality is much better with s-video. Alternatively, you can connect a scan converter to the VGA output. Scan converters are available from [ADS Technologies](#), [AITech](#), [Antec](#), [AverLogic](#), [AverMedia](#), [Communications Specialties](#), [Digital Vision](#), [Focus Enhancements](#), [Key Digital Systems](#), [RGB Products](#), and others. Make sure the scan converter can handle the display resolution you have chosen: 640x480, 800x600, etc., although keep in mind that even 800x600 is beyond the ability of a standard TV, so higher resolutions won't make the TV picture better.

The quality of video from a PC depends on the decoder, the graphics card, the TV encoder chip, and other factors. The RGB output of the VGA card in computers is at a different frequency than standard component RGB video, so it can't be directly connected to most RGB video monitors. If the decoder card or the sound card has Dolby Digital or DTS output, you can connect to your A/V receiver to get multichannel audio.

A DVD PC connected to a progressive-scan monitor or video projector, instead of a standard TV, usually looks much better than a consumer player. See [2.9](#). Also see the [Home Theater Computers](#) forum at AVS.

For remote control of DVD playback on your PC, check out [Animax](#) *Anir Multimedia Magic*, [Evation](#) *IRMan*, [Multimedia Studio](#) *Miro MediaRemote*, [Packard Bell](#) *RemoteMedia*, [RealMagic](#) *Remote Control*, and [X10](#) *MouseRemote*. Many remotes are supported by [Visual Domain](#)'s *Remote Selector* software.

[4.1.1] Can I play DVD-Audio discs on my computer?

Usually not. DVD-ROM drives can read DVD-Audio discs, but as of early 2003 only the [Sound Blaster Audigy 2](#) card includes the software needed to play DVD-Audio on a computer. Part of the reason for general lack of support is that very few computers provide the high quality audio environment needed to take advantage of DVD-Audio fidelity.

It's possible that Microsoft could add DVD-Audio playback to a future version of Windows, in which case you would only need to download some inexpensive decoding software to get DVD-Audio playback.

[4.2] What are the features and speeds of DVD drives?

Unlike CD-ROM drives, which took years to move up to 2x, 3x, and faster spin rates, faster DVD-ROM drives began appearing in the first year. A 1x DVD-ROM drive provides a data transfer rate of 1.321 MB/s ($11.08 \times 10^6 / 8 / 2^{20}$) with burst transfer rates of up to 12 MB/s or higher. The data transfer rate from a DVD-ROM disc at 1x speed is roughly equivalent to a 9x CD-ROM drive (1x CD-ROM data transfer rate is 150 KB/s, or 0.146 MB/s). DVD physical spin rate is about 3 times faster than CD (that is, 1x DVD spin ~ 3x CD spin), but most DVD-ROM drives increase motor speed when reading CD-ROMs, achieving 12x or faster performance. A drive listed as "16x/40x" reads a DVD at 16 times normal, or a CD at 40 times normal. DVD-ROM drives are available in 1x, 2x, 4x, 4.8x, 5x, 6x, 8x, 10x, and 16x speeds, although they usually don't achieve sustained transfer at their full rating. The "max" in DVD and CD speed ratings means that the listed speed only applies when reading data at the outer edge of the disc, which moves faster. The average data rate is lower than the max rate. Most 1x DVD-ROM drives have a seek time of 85-200 ms and access time of 90-250 ms. Newer drives have seek times as low as 45 ms.

Likewise, DVD recordable drives have steadily increased in write speed. 16x DVD writers began to be widely available in 2004. Note that recordable discs have different speed ratings (see [4.3.11](#)).

Current thinking is that DVD drive speeds have topped out at 16x, since disc wobbling and other physical factors become a problem at faster speeds.

DVD drive speed	Data rate	Disc write time*	Equivalent CD rate	CD reading speed
1x	11.08 Mbps (1.32 MB/s)	53 min.	9x	8x-18x
2x	22.16 Mbps (2.64 MB/s)	27 min.	18x	20x-24x
4x	44.32 Mbps (5.28 MB/s)	14 min.	36x	24x-32x
5x	55.40 Mbps (6.60 MB/s)	11 min.	45x	24x-32x
6x	66.48 Mbps (7.93 MB/s)	9 min.	54x	24x-32x
8x	88.64 Mbps (10.57 MB/s)	7 min.	72x	32x-40x
10x	110.80 Mbps (13.21 MB/s)	6 min.	90x	32x-40x
16x	177.28 Mbps (21.13 MB/s)	4 min.	144x	32x-40x

* "Disc write time" is the approximate theoretical time it takes to write a DVD-5, which doesn't include software overhead, time to write leadout, etc. In practice, writing will take longer.

The bigger the cache (memory buffer) in a DVD-ROM drive, the faster it can supply data to the computer. This is useful primarily for data, not video. It may reduce or eliminate the pause during layer changes, but has no effect on video quality.

Rewritable DVD drives (see [4.3](#)) write at about half their advertised speed when the data verification feature is turned on, which reads each block of data after it is written. Verification is usually on by default in DVD-RAM drives. Turning it off will speed up writing. Whether this endangers your data is a subject of debate. Verification is off in DVD-RW and DVD+RW drives.

In order to maintain constant linear density, typical CD-ROM and DVD-ROM drives spin the disc more slowly when reading or writing near the outside where there is more physical surface in each track. (This is called CLV, constant linear velocity.) Some faster drives keep the rotational speed constant and use a buffer to deal with the differences in data readout or writeout speed. (This is called CAV, constant angular velocity.) In CAV drives, the data is read or written fastest at the outside of the disc, which is why specifications often list "max speed."

Note: When playing movies, a fast DVD drive gains you nothing more than possibly smoother scanning and faster searching. Speeds above 1x do not improve video quality from DVD-Video discs. Higher speeds only make a difference when reading computer data, such as when playing a multimedia game or when using a database.

Connectivity of DVD drives is similar to that of CD drives: EIDE (ATAPI), SCSI-2, etc. All DVD drives have audio connections for playing audio CDs. No DVD drives have been announced with their own DVD audio or video outputs (which would require internal audio/video decoding hardware).

Almost all DVD-Video and DVD-ROM discs use the *UDF bridge* format, which is a combination of the DVD *MicroUDF* (subset of UDF 1.02) and ISO 9660 file systems. The [OSTA](#) UDF file system will eventually replace the ISO 9660 system originally designed for CD-ROMs, but the bridge format provides backwards compatibility until more operating systems support UDF.

4.2.1 What is the audio output connector on a DVD drive for?

DVD-ROM drives and DVD recordable drives have an RCA connector or a 4-pin flat (Molex) connector to send analog audio to the audio card in the PC. This is just like the connector on a CD drive, and in fact it's only for playing audio CDs. The audio from DVDs comes through the computer, not out of the drive. Playing audio from a CD used to require the analog audio output, but most PCs can now play digital audio directly from the CD so the analog connector is not needed.

[4.3] What about recordable DVD: DVD-R, DVD-RAM, DVD-RW, DVD+RW, and DVD+R?

There are six recordable versions of DVD: DVD-R for General, DVD-R for Authoring, DVD-RAM, DVD-RW, DVD+RW, and DVD+R. DVD-R and DVD+R can record data once, like CD-R, whereas DVD-RAM, DVD-RW, and DVD+RW can be rewritten thousands of times, like CD-RW. DVD-R was first available in fall 1997. DVD-RAM followed in summer 1998. DVD-RW came out in Japan in December 1999, but was not available in the U.S. until spring 2001. DVD+RW became available in fall 2001. DVD+R was released in mid 2002.

Recordable DVD was first available for use on computers only. Home DVD video recorders (see [1.14](#)) appeared worldwide in 2000. This FAQ uses the terms "drive" or "burner" to refer to recordable computer drives and the term "video recorder" to refer to home set-top recorders.

DVD-RAM is more of a removable storage device for computers than a video recording format, although it has become widely used in DVD video recorders because of the flexibility it provides in editing a recording. The other two recordable format families (DVD-R/RW and DVD+R/RW) are essentially in competition with each other. The market will determine which of them succeeds or if they end up coexisting or merging. There are many claims that one or the other format is better, but they are actually very similar. In 2003 many companies began making drives that could record in both "dash" and "plus" format.

Each writable DVD format is covered briefly below. See section [6.2.3](#) for hardware manufacturers. For more on writable DVD see Dana Parker's [Writable DVD - A Guide For the Perplexed](#) (very good, although a bit out of date). More information on writable DVD formats is available at industry associations: [RW Products Promotion Initiative \(RWPPI\)](#), [Recordable DVD Council \(RDVDC\)](#), and [DVD+RW Alliance](#). Also [DVD Writers](#) and [DVDplusRW.org](#). If you're interested in writable DVD for data storage, visit Steve Rothman's [DVD-DATA](#) page for FAQ and mailing list info.

[4.3.1] Is it true there are compatibility problems with recordable DVD formats?

Yes. None of the writable formats are fully compatible with each other or even with existing drives and players. In other words, a DVD+R/RW drive can't write a DVD-R or DVD-RW disc, and vice versa (unless it's a combo drive that writes both formats). As time goes by the different formats are becoming more compatible and more intermixed. A player with the DVD Forum's *DVD Multi* is guaranteed to read DVD-R, DVD-RW, and DVD-RAM discs, and a *DVD Multi* recorder can record using all three formats. Some new "super combo" drives can record in both plus and dash format, and a few "super multi" drives can record all 5 disc types (DVD-R, DVD-RW, DVD+R, DVD+RW, and DVD-RAM).

In addition, not all players and drives can read recorded discs. The basic problem is that recordable discs have different reflectivity than pressed discs (the pre-recorded kind you buy in a store -- see [5](#)), and not all players have been correctly designed to read them. There are compatibility lists at [CustomFlix](#), [DVDMadeEasy](#), [DVDRHelp](#), [HomeMovie.com](#), [Apple](#), [YesVideo.com](#), and elsewhere that indicate player compatibility with DVD-R and DVD-RW discs. [DVDplusRW.org](#) maintains a list of DVD+RW compatible [players](#) and [drives](#). (Note: test results vary depending on media quality, handling, writing conditions, player tolerances, and so on. The indications of compatibility in these lists are often anecdotal in nature and are only general guidelines.) There is insignificant compatibility difference between the "dash" and "plus" formats (see [4.3.6](#)). There are much bigger compatibility differences between brands, so be careful about buying cheap discs.

Very roughly, DVD-R and DVD+R discs work in about 85% of existing drives and players, while DVD-RW and DVD+RW discs work in around 80%. The situation is steadily improving. In another few years compatibility problems will mostly be behind us, just as with CD-R (did you know that early CD-Rs had all kinds of compatibility problems?).

Here is a summary of recordable DVD compatibility. Below each drive is a column indicating how well it can read or write each format (for simplicity, "doesn't write" is implied if not otherwise specified).

	DVD unit	DVD-R(G) unit	DVD-R(A) unit	DVD-RW unit	DVD-RAM unit	DVD+RW unit
DVD-ROM disc	reads	reads	reads	reads	reads	reads
DVD-R(G)	often reads	reads, writes	reads	reads, writes	reads	reads

disc						
DVD-R(A) disc	usually reads	reads	reads, writes	reads	reads	reads
DVD-RW disc	often reads	reads	reads	reads, writes	usually reads	usually reads
DVD-RAM disc	rarely reads	doesn't read	doesn't read	doesn't read	reads, writes	doesn't read
DVD+RW disc	usually reads	usually reads	usually reads	usually reads	usually reads	reads, writes
DVD+R disc	often reads	usually reads	usually reads	usually reads	reads	reads, may write

The author of this DVD FAQ is a member of the [OSTA/DVDA/NIST](#) Recordable DVD Compatibility Study committee. A report on [phase 1 DVD-ROM drive testing](#) is available from NIST.

[4.3.2] DVD-R

DVD-R (which is pronounced "dash R" not "minus R") uses organic dye technology, like CD-R, and is compatible with most DVD drives and players. First-generation capacity was 3.95 billion bytes, later extended to 4.7 billion bytes. Matching the 4.7G capacity of DVD-ROM was crucial for desktop DVD production. In early 2000 the format was split into an "authoring" version and a "general" version. The general version, intended for home use, writes with a cheaper 650-nm laser, the same as DVD-RAM. DVD-R(A) is intended for professional development and uses a 635-nm laser. DVD-R(A) discs are not writable in DVD-R(G) recorders, and vice-versa, but both kinds of discs are readable in most DVD players and drives. The main differences, in addition to recording wavelength, are that DVD-R(G) uses decrementing pre-pit addresses, a pre-stamped (version 1.0) or pre-recorded (version 1.1) control area, CPRM (see [1.11](#)), and allows double-sided discs. A third version for "special authoring," allowing protected movie content to be recorded on DVD-R media, was considered but will probably not happen.

Pioneer released 3.95G DVD-R(A) 1.0 drives in October 1997 (about 6 months late) for \$17,000. New 4.7G DVD-R(A) 1.9 drives appeared in limited quantities in May 1999 (about 6 months late) for \$5,400. Version 2.0 drives became available in fall 2000. Version 1.9 drives can be upgraded to 2.0 via downloaded software. (This removes the 2,500 hour recording limit.) New 2.0 [4.7G] media (with newer copy protection features), can only be written in 2.0 drives. 1.9 media (and old 1.0 [3.95G] media) can still be written in 2.0 drives. Version 1.0 (3.95G) discs are still available, and can be recorded in Pioneer DVD-R(A) drives. Although 3.95G discs hold less data, they are more compatible with existing players and drives.

Pioneer's DVR-A03 DVD-R(G) drive was released in May 2001 for under \$1000. By August it was available for under \$700, and by February 2002 it was under \$400. The same drive (model DVR-103) was built into certain Apple Macs and Compaq PCs. Many companies now produce DVD-RW drives, all of which write CD-R/RW. As of mid 2002 DVD-RW drives were selling for under \$200. Most DVD-RAM drives also write DVD-R discs, some also write DVD-RW discs. Many new drives write both DVD-R/RW and DVD+R/RW.

Pioneer released a professional DVD video recorder in 2002. It sells for about \$3000 and provides component video (YPbPr) and 1394 (DV) inputs (along with s-video and composite). It has 1-hour (10 Mbps) and 2-hour (5 Mbps) recording modes, and includes a 2-channel Dolby Digital audio encoder.

Prices for blank DVD-R(A) discs are \$10 to \$25 (down from the original \$50), although cheaper discs seem to have more compatibility problems. Prices for blank DVD-R(G) discs are \$2 to \$6. Blank media are made by CMC Magnetics, Fuji, Hitachi Maxell, Mitsubishi, Mitsui, Pioneer, Ricoh, Ritek, Taiyo Yuden, Sony, TDK, Verbatim, Victor, and others.

The DVD-R 1.0 format is standardized in [ECMA-279](#). Andy Parsons at Pioneer has written a [white paper](#) that explains the differences between DVD-R(G) and DVD-R(A).

It's possible to submit DVD-R(A) and DVD-R(G) discs for replication, with limitations. First, not all replicators will accept submissions on DVD-R. Second, there can be problems with compatibility and data loss when using DVD-R, so it's best to generate a checksum that the replicator can verify. Third, DVD-R does not directly support CSS, regions, and Macrovision. Support for this is being added to DVD-R(A) with the cutting master format (CMF), which stores DDP information in the control area, but it will take a while before many authoring software programs and replicators support CMF.

[4.3.3] DVD-RW

DVD-RW (formerly DVD-R/W and also briefly known as DVD-ER) is a phase-change erasable format. Developed by Pioneer based on DVD-R, using similar track pitch, mark length, and rotation control, DVD-RW is playable in many DVD drives and players. (Some drives and players are confused by DVD-RW media's lower reflectivity into thinking it's a dual-layer disc. In other cases the drive or player doesn't recognize the disc format code and doesn't even try to read the disc. Simple firmware upgrades can solve both problems.) DVD-RW uses groove recording with address info on land areas for synchronization at write time (land data is ignored during reading). Capacity is 4.7 billion bytes. DVD-RW discs can be rewritten about 1,000 times.

In December 1999, Pioneer released DVD-RW home video recorders in Japan. The units cost 250,000 yen (about \$2,500) and blank discs cost 3,000 yen (about \$30). Since the recorder used the new DVD-VR (video recording) format, the discs wouldn't play in existing players (the discs were *physically* compatible, but not *logically* compatible). Recording time varies from 1 hour to 6 hours, depending on quality. A new version of the recorder was later released that also recorded on DVD-R(G) discs and used the DVD-Video format for better compatibility with existing players.

DVD-RW drives write DVD-R, DVD-RW, CD-R, and CD-RW discs. DVD-RW disc prices are around \$5-\$10 (down from the original \$30). Blank media is being made by CMC Magnetics, Hitachi Maxell, Mitsubishi, Mitsui, Pioneer, Ricoh, Ritek, Sony, Taiyo Yuden, TDK, Verbatim, Victor, and others.

There are three kinds of DVD-RW discs. All are 4.7G capacity. Version 1.0 discs, rarely found outside of Japan, have an embossed lead-in (to prevent copying of CSS information), which causes compatibility problems. Version 1.1 discs have a pre-recorded lead-in that improves compatibility. Version 1.1 discs also come in a "B" version that carries a unique ID in the BCA for use with CPRM. B-type discs are required when copying certain kinds of protected video. (See [1.11](#) for more on CPRM; [3.11](#) for more on BCA.)

Note: The Apple SuperDrive (even with older 1.22 firmware) can write to DVD-RW discs, but not from the iDVD application. You must use a different software utility, such as Toast, to write to DVD-RW discs.

[4.3.4] DVD-RAM

DVD-RAM, with an initial storage capacity of 2.58 billion bytes, later increased to 4.7, uses phase-change dual (PD) technology with some magneto-optic (MO) features mixed in. DVD-RAM is the best suited of the writable DVD formats for use in computers, because of its defect management and zoned CLV format for rapid access. However, it's not compatible with most drives and players (because of defect management, reflectivity differences, and minor format differences). A wobbled groove is used to provide clocking data, with marks written in both the groove and the land between grooves. The grooves and pre-embossed sector headers are molded into the disc during manufacturing. Single-sided DVD-RAM discs come with or without cartridges. There are two types of cartridges: type 1 is sealed, type 2 allows the disc to be removed. Discs can only be written while in the cartridge. Double-sided DVD-RAM discs were initially available in sealed cartridges only, but now come in removable versions as well. Cartridge dimensions are 124.6 mm x 135.5 mm x 8.0 mm. DVD-RAM can be rewritten more than 100,000 times, and the discs are expected to last at least 30 years.

DVD-RAM 1.0 drives appeared in June 1998 (about 6 months late) for \$500 to \$800, with blank discs at about \$30 for single-sided and \$45 for double-sided. The first DVD-ROM drive to read DVD-RAM discs was released by Panasonic in 1999 (SR-8583, 5x DVD-ROM, 32x CD). Hitachi's GD-5000 drive, released in late 1999, also reads DVD-RAM discs. Blank DVD-RAM media is manufactured by CMC Magnetics, Hitachi Maxell, Eastman Kodak, Mitsubishi, Mitsui, Ritek, TDK, and others.

The spec for DVD-RAM version 2.0, with a capacity of 4.7 billion bytes per side, was published in October 1999. The first drives appeared in June 2000 at about the same price as DVD-RAM 1.0 drives. Single-sided discs were priced around \$25, and double-sided discs were around \$30. Disc prices were under \$10 and retail drive prices were under \$200 by 2003. DVD-RAM 2.0 also specifies 8-cm discs and cartridges for portable uses such as digital camcorders. Future DVD-RAM discs may use a contrast enhancement layer and a thermal buffer layer to achieve higher density.

Samsung and C-Cube made a technology demonstration (not a product announcement) in October 1999 of a DVD-RAM video recorder using the new DVD-VR format (see DVD-RW section above for more about DVD-VR). Panasonic demonstrated a \$3,000 DVD-RAM video recorder at CES in January 2000. It appeared in the U.S. in September for \$4,000 (model DMR-E10). At the beginning of 2001, Hitachi and Panasonic released DVD camcorders that use small DVD-RAM discs. The instant access and on-the-fly editing and deleting capabilities of the DVD camcorders are impressive. Panasonic's 2nd-generation DVD-RAM video recorder appeared in October 2001 for \$1,500 and also wrote to DVD-R discs.

The DVD-RAM 1.0 format is standardized in [ECMA-272](#) and [ECMA-273](#).

[4.3.4.1] How do I remove a DVD-RAM type 2 disc from the cartridge?

Type 2 DVD-RAM cartridges allow the disc to be removed so that it can be played in standard players or drives. (However, most players and drives still won't be able to read the disc -- see [4.3.1](#).)

First break (yes, break) the locking pin by pushing on it with a pointed object such as a ballpoint pen. Remove the locking pin. Unlatch the cover by using a pointed object to press the indentation on the back left corner of the cartridge. Data is recorded on the unprinted side of the disc -- do not touch it. When you put the bare disc back the cartridge, make sure the printed side of the shutter and the printed side of the disc face the same direction.

Most DVD-RAM drives will not allow you to write to a bare disc. Some will not allow you to write to a cartridge if the disc has been removed.

[4.3.5] DVD+RW and DVD+R

DVD+RW is an erasable format based on CD-RW technology. It became available in late 2001. DVD+RW is supported by Philips, Sony, Hewlett-Packard, Dell, Ricoh, Yamaha, and others. It is not supported by the DVD Forum (even though most of the DVD+RW companies are members), but the Forum has no power to set standards. DVD+RW drives read DVD-ROMs and CDs, and usually read DVD-Rs and DVD-RWs, but do not read or write DVD-RAM discs. DVD+RW drives also write CD-Rs and CD-RWs. DVD+RW discs, which hold 4.7 billion bytes per side, are readable in many existing DVD-Video players and DVD-ROM drives. (They run into the same reflectivity and disc format recognition problems as DVD-RW.)

DVD+RW backers claimed in 1997 that the format would be used only for computer data, not home video, but this was apparently a smokescreen intended to placate the DVD Forum and competitors. The original 1.0 format, which held 3 billion bytes (2.8 gigabytes) per side and was not compatible with any existing players and drives, was abandoned in late 1999.

The DVD+RW format uses phase-change media with a high-frequency wobbled groove that allows it to eliminate linking sectors. This, plus the option of no defect management, allows DVD+RW discs to be written in a way that is compatible with many existing DVD readers. The DVD+RW specification allows for either CLV format for sequential video access (read at CAV speeds by the drive) or CAV format for random access, but CAV recording is not supported by any current hardware. DVD+R discs can only be recorded in CLV mode. Only CLV-formatted discs can be read in standard DVD drives and players. DVD+RW media can be rewritten about 1,000 times (down from 100,000 times in the original 1.0 version).

DVD+R is a write-once variation of DVD+RW, which appeared in mid 2002. It's a dye-based medium, like DVD-R, so it has similar compatibility as DVD-R. Original DVD+RW drives did not fulfill the promise of a simple upgrade to add DVD+R writing support, so they have to be replaced with newer models. The original Philips DVD+RW video recorders, on the other hand, can be customer-upgraded to write +R discs.

Philips announced a DVD+RW home video recorder for late 2001. The Philips recorder uses the DVD-Video format, so discs play in many existing players. HP announced a \$600 DVD+RW drive (made by Ricoh) and \$16 DVD+RW discs for September 2001. HP's drive reads DVDs at 8x and CDs at 32x, and writes to DVD+RW at 2.4x, CD-R at 12x, and CD-RW at 10x.

In 2003 DVD+R discs cost around \$2 to \$6 and DVD+RW discs cost around \$5 to \$10. DVD+RW media is produced by CMC Magnetics, Hewlett-Packard, MCC/Verbatim, Memorex, Mitsubishi, Optodisc, Philips, Ricoh, Ritek, and Sony.

More DVD+RW information is at www.dvdrw.com and www.dvdplusrw.org. The obsolete DVD+RW 1.0 format is standardized in [ECMA-274](#).

[4.3.6] Which recordable DVD format should I buy?

As explained in the previous sections, there are two main formats: "dash" (DVD-R/RW) and "plus" (DVD+R/RW). There's not much difference between them. They both record data and video, and they both read back data and play back video. Both formats are available as recordable drives for computers and as home video recorders. In spite of claims that one format is more compatible with players and drives, both formats are similarly compatible (see [4.3.1](#)). There are speed differences, but it's a game of leapfrog. One format will come out with faster write speeds, then the other one will match it or surpass it. In 2003, drives reached 8x speeds. 16x is the theoretical maximum, so both formats will soon hit the limit.

The biggest thing to worry about is that DVD-RW drives only record on -R and -RW discs, and DVD+RW drives only record on +R and +RW discs, so you have to make sure you get the right kind of blank discs. You may worry that one of the formats might "win" and the other format could disappear, leaving you with abandoned hardware. This is not very likely, since both formats are doing well. Luckily there is a simple solution to both concerns: buy a dual-format, or "combo" drive. Many companies make DVD-/RW drives that write to both kinds of discs. Dual-format drives cost a bit more, but it's cheap insurance.

The DVD+RW format has a few advantages when used in a computer, but if data backup or access speed is important, also consider the DVD-RAM format. DVD-RAM is fast and reliable, and the discs have an optional cartridge to help protect data. Most DVD-RAM drives also write DVD-R/RW discs, and some super combo drives write all three formats.

[4.3.7] Other recordable optical formats

Competitors to recordable DVD were announced but never appeared, thanks in part to the success of the entire DVD family. These formats included AS-MO (formerly MO7), which was to hold 5 to 6 billion bytes, and NEC's Multimedia Video Disc (MVDisc, formerly MMVF, Multimedia Video File), which was to hold 5.2 billion bytes and was targeted at home recording. ASMO drives were expected to read DVD-ROM and compatible writable formats, but not DVD-RAM. MVDisc was similar to DVD-RW and DVD+RW, using two bonded 0.6mm phase-change substrates, land and groove recording, and a 640nm laser, but contrary to initial reports, the drives were not expected to be able to read DVD-ROM or compatible discs.

There was also FMD (see [2.13](#)). And there are new HD formats (see [6.5](#)).

[4.3.8] How long does DVD recording take?

The time it takes to burn a DVD depends on the speed of the recorder and the amount of data. Playing time of the video may have little to do with recording time, since a half hour at high data rates can take more space than an hour at low data rates. A 2x recorder, running at 22 Mbps, can write a full 4.7G DVD in about 30 minutes. A 4x recorder can do it in about 15 minutes.

Note that the -R/RW format often writes a full lead-out to the diameter required by the DVD spec, so small amounts of data (like a very short video clip) may take the same amount of time as large amounts.

[4.3.9] Which color of recordable DVD is best?

Different colors of recordable CDs and DVDs come from the combination of the reflective metal layer (gold or silver) and the dye used in the recording layer (cyanine [blue], phthalocyanine [clear], azo [dark blue], formazan [green], etc.). Judging DVD quality by color is like judging bell pepper quality by color (is yellow better than red or green?). You may find that some color discs seem to work better in some players, but you'll also find that there is little correlation between color and readability across multiple brands of disc. Other factors such as manufacturing quality and chemical formulation have much more of an effect on how well a disc records and plays back.

Color does indicate longevity, since some dyes (such as phthalocyanine and azo) are more stable and last longer. See [3.12](#).

[4.3.10] When will recordable DVD-9s be available?

Dual-layer recording is much trickier than single-layer recording. However, dual-layer recording techniques developed for Blu-ray (see [3.13](#)) have been adapted for recordable DVD. Write-once (+R and -R) recordable DVD-9 discs, which hold almost double the amount of data or recording time (see [3.3](#)), should show up around the end of 2004. Dual-layer rewritable discs are harder to get working, but they may show up a year or two later. Recordable drives will cost about the same as regular drives (since only firmware changes are required to record two layers) and the discs will cost between 1.2 to 3 times as much as single-layer discs.

Philips first demonstrated dual-layer +R at CEATEC in Japan in October 2003. They expect the discs to be readable in about 70% of existing players and drives. Also in October, Pioneer announced a dual-layer version of -R, but they did not demonstrate it.

[4.3.11] What does 2x, 4x, 16x, and so on mean on recordable discs, and which one should I use?

Recordable discs come in different speed ratings (2x = twice standard write speed, 8x = eight times standard speed, and so forth). The speed ratings of blank discs match the speed ratings of drives (see [4.2](#)). When faster drives become available, new discs are designed to work with the new drives as well as older drives. This means you should use discs that are rated at or above the speed of your drive. For example, if you have a 4x drive you should use 4x or faster discs, not 1x or 2x.

Almost all home DVD video recorders use 1x drives, so any speed of discs should work.

[4.4] Why can't I take a screenshot of DVD video? Why do I get a pink or black square?

Most DVD PCs, even those with software decoders, use video overlay hardware to insert the video directly into the VGA signal. This is an efficient way to handle the very high bandwidth of full-motion video. Some decoder cards, such as the Creative Labs Encore Dxr series and the Sigma Designs Hollywood series, use a pass-through cable that overlays the video into the analog VGA signal after it comes out of the video display card. Video overlay uses a technique called *colorkey* to selectively replace a specified pixel color (often magenta or near-black) with video content. Anywhere a colorkey pixel appears in the computer graphics video, it's replaced by video from the DVD decoder. This process occurs "downstream" from the computer's video memory, so if you try to take a screenshot (which grabs pixels from video RAM), all you get is a solid square of the colorkey color.

Hardware acceleration must be turned off before screen capture will work. This makes some decoders write to standard video memory. Utilities such as [Creative Softworx](#), [HyperSnap](#), and [SD Capture](#) can then grab still pictures. Some player applications such as PowerDVD and the Windows Me player can take screenshots if hardware acceleration is turned off.

[4.5] Why can't I play movies copied to my hard drive?

Almost all movies are encrypted with CSS copy protection (see [1.11](#)). Decryption keys are stored in the normally inaccessible lead-in area of the disc. You'll usually get an error if you try to copy the contents of an encrypted DVD to a hard drive. However, if you have used a software player to play the movie it will have authenticated the disc in the drive, allowing you to copy without error, but the encryption keys will not be copied. If you try to play the copied VOB files, the decoder will request the keys from the DVD-ROM drive and will fail. You may get the message "Cannot play copy-protected files".

[4.6] Why do I have problems playing DVDs on my computer?

There are thousands of answers to this question, but here are some basic troubleshooting steps to help you track down problems such as jerky playback, pauses, error messages, and so on.

- Get updated software. Driver bugs are the biggest cause of playback problems, ranging from freezes to bogus error messages about regions. Go to the support section on the Web sites of your equipment manufacturers and make sure you have the latest drivers for your graphics adapter, audio card, and DVD decoder (if you have a hardware decoder). Also make sure you have the latest update of the player program.
Apple has released numerous updates for audio drivers and the DVD player application. Make sure you have the latest versions. Go to the [downloads](#) page and search for DVD.
- If you have multiple DVD players installed, especially trial versions that have expired, uninstall all but one of them. (You may then have to reinstall your preferred player.)
- If you have problems loading a DVD on a Mac, hold down the Command, Option, and I keys when inserting the disk. (This mounts the disc using ISO 9660 instead of UDF.)
- Make sure DMA or SDT is turned on. In Windows, go into the System Properties Device Manager, choose CD-ROM, open the CD/DVD driver properties, choose the Settings tab, and make sure the DMA box (for IDE drives) or the Sync Data Transfer box (for SCSI drives) is checked. Download [CD Speed](#) to check the performance of your drive (if it's below 1x, you have problems).
Caution: You may run into problems turning DMA on, especially with an AMD K6 CPU or VIA chipset. Check for a BIOS upgrade, a drive controller upgrade, a bus mastering driver upgrade, and a CD/DVD-ROM driver upgrade from your system manufacturer before turning DMA on. If the drive disappears, reboot in safe mode, uncheck DMA, and reboot again. You may have to tell Windows to restore the registry settings from its last registry backup.

- If you get an error about unavailable overlay surface, reduce the display resolution or number of colors (right-click desktop, choose Settings tab).
- Try turning off programs that are running in the background. (In Windows, close or exit applets in the system tray -- the icons in the lower right corner. In Mac OS, turn off AppleTalk, file sharing, and virtual memory.)
- Allocate more memory to the Apple DVD Player.
- If you are using a SCSI DVD-ROM drive, make sure that it's the first or last device in the SCSI chain. If it's the last device, make sure it's terminated.
- Reinstall the Windows bus mastering drivers. (Delete them from the device manager and let Windows ask for original disc.)
- Bad video when connecting to a TV could be from too long a cable or from interference or a ground loop. See [3.2.2](#).

More information on specific graphics cards and driver updates:

- [Nvidia DVD Zone](#)
- [Nvidia GeForce 256 FAQ](#)

[4.7] Can I stream DVD over a network or the Internet?

Short answer: Not if the disc is copy protected.

With a fast enough network (100 Mbps or better, with good performance and low traffic) and a high-performance server, it's possible to stream DVD-Video from a server to client stations. If the source on the server is a DVD-ROM drive (or jukebox), then more than one user simultaneously accessing the same disc will cause breaks in the video unless the server has a fast DVD-ROM drive and a very good caching system designed for streaming video.

A big problem is that CSS-encrypted movies (see [1.11](#)) can't be remotely sourced because of security issues. The CSS license does not allow decrypted video to be sent over an accessible bus or network, so the decoder has to be on the remote PC. If the decoder has a secure channel to perform authentication with the drive on the server, then it's possible to stream encrypted video over a network to be decrypted and decoded remotely. (But so far almost no decoders can do this.)

One solution is the [VideoLAN](#) project which runs on GNU/Linux/Unix, BeOS, Mac OS X, and other operating systems. It includes a player with built-in CSS decryption. Although the code is different from DeCSS, it's an unlicensed implementation and is probably illegal in most countries (see [4.8](#)).

An alternative approach is to decode the video at the server and send it to individual stations via separate cables (usually RF). The advantage is that performance is very good, but the disadvantage is that DVD interactivity is usually limited, and every viewer connected to a single drive/decoder must watch the same thing at the same time.

Many companies provide support for streaming video (MPEG-1, MPEG-2, MPEG-4, etc.) over LANs, but only from files or realtime encoders, not from DVD-Video discs.

The Internet is a different matter. It takes over a week to download the contents of a single-layer DVD using a 56k modem. It takes about 7 hours on a T1 line. Cable modems theoretically cut the time down to a few hours, but if other users in the same neighborhood have cable modems, bandwidth could drop significantly. [Jim's prediction, made in 2001: the average DVD viewing household won't have sufficiently fast Internet connections before 2007 at the earliest. Around that time there will be a new high-definition version of DVD with double the data rate, which will once again exceed the capacity of the typical Internet connection.]

[4.8] What is DeCSS?

CSS (Content Scrambling System) is an encryption and authentication scheme intended to prevent DVD movies from being digitally copied. See [1.11](#) for details. DeCSS refers to the general process of defeating CSS, as well as to DeCSS source code and programs.

Computer software to decrypt CSS was released to the Internet in October 1999 (see Dana Parker's article at www.emediapro.net/news99/news111.html), although other "ripping" methods were available before that (see [6.4.2](#)). The difference between circumventing CSS encryption with DeCSS and intercepting decrypted, decompressed video with a DVD ripper is that DeCSS can be considered illegal under the [DMCA](#) and the [WIPO](#) treaties. The DeCSS information can be used to "guess" at master keys, such that a standard PC can generate the entire list of 409 keys, rendering the key secrecy process useless.

In any case, there's not much appeal to being able to copy a set of movie files (often without menus and other DVD special features) that would take over a week to download on a 56K modem and would fill up a 6G hard disk or a dozen CD-Rs. An alternative is to recompress the video with a different encoding format such as DivX (see [2.10](#)) so that it will take less space, but this often results in significantly reduced picture quality. In spite of lower data rates of DivX et al, the time and effort it takes to find and download the files is not worth the bother for most movie viewers. The reality is that most people ripping and downloading DVDs are doing it for the challenge, not to avoid buying discs.

The supporters of DeCSS point out that it was only developed to allow DVD movies to be played on the Linux operating system, which had been excluded from CSS licensing because of its open-source nature. This is specifically allowed by DMCA and WIPO laws. However, the DeCSS.exe program posted on the Internet is a Windows application that decrypts movie files. The lack of differentiation between the DeCSS process in Linux and the DeCSS.exe Windows application is hurting the cause of DeCSS backers, since DeCSS.exe can be used in the process of copying and illegally distributing movies from DVD. See Tom Vogt's [DeCSS central](#) for more information on DeCSS.

Worthy of note is that DVD piracy was around long before DeCSS. Serious DVD pirates can copy the disc bit for bit, including the normally unreadable lead in (this can be done with a specially modified drive), or copy the video output from a standard DVD player, or get a copy of the video from another source such as laserdisc, VHS, or a camcorder smuggled into a theater. It's certainly true that DVD piracy is a problem, but DeCSS has little to do with it.

Shortly after the appearance of DeCSS, the [DVD CCA](#) filed a lawsuit and requested a temporary injunction in an attempt to prevent Web sites from posting (or even linking to!) DeCSS information. The request was denied by a California court on December 29, 1999. On January 14, 2000, the seven top U.S. movie studios (Disney, MGM, Paramount, Sony [Columbia/TriStar], Time Warner, Twentieth Century Fox, and Universal), backed by the [MPAA](#), filed lawsuits in Connecticut and New York in a further attempt to stop the distribution of DeCSS on Web sites in those states. On January 21, the judge for the New York suit granted a [preliminary injunction](#), and on January 24, the judge for the CCA suit in California reversed his earlier decision and likewise granted a [preliminary injunction](#). In both cases, the judges ruled that the injunction applied only to sites with DeCSS information, not to linking sites. (Good thing, since this FAQ links to DeCSS sites!) The CCA suit is based on misappropriation of trade secrets (somewhat shaky ground), while the MPAA suits are based on copyright circumvention. On January 24, 16-year old Jon Johansen, the Norwegian programmer who first distributed DeCSS, was questioned by local police who raided his house and confiscated his computer equipment and cell phone. Johansen says the actual cracking work was done by two anonymous programmers, one German and one Dutch, who call themselves Masters of Reverse Engineering (MoRE).

This all seems to be a losing battle, since the DeCSS source code is available on T-shirts and was made publicly available by the DVD CCA itself in [court records](#)--oops! See [Fire, Work With Me](#) for a facetious look at the broad issue.

[4.9] How do I play DVD video in HTML, PowerPoint, Director, VB, etc.?

A variety of multimedia development/authoring programs can be extended to play video from a DVD, either as titles and chapters from a DVD-Video volume, or as MPEG-2 files. In Windows, this is usually done with ActiveX controls. On the Mac, until DVD-Video support is added to QuickTime, the options are limited. Newer versions of the Apple DVD Player can be controlled with AppleScript.

DVD-Video and MPEG-2 video can be played back in an HTML page in Microsoft Internet Explorer using many different ActiveX controls (see table). Some ActiveX controls also work in PowerPoint, Visual Basic, and other ActiveX hosts. Netscape Navigator is out of the game until it supports ActiveX objects. Simple MPEG-2 playback can be done in PowerPoint using the Insert Movie feature (requires that a DirectShow-compatible MPEG-2 decoder be installed). DVD and MPEG-2 playback can be integrated into Macromedia Director using specialized Xtras.

	Price	HTML (IE only)	PowerPoint	ActiveX host (VB, etc.)	Director
Microsoft MSWebDVD or MSVidWebDVD (see MSDN overview)	free	yes	yes	yes	no
Microsoft Windows Media Player 6.1 (docs in Windows Media SDK)	free	yes	no	no	no
InterActual PC Friendly	not available	certain versions	no	no	no
InterActual Player 2.0	\$2000 and up	yes	yes	yes	yes?
SpinWare iControl	PE: \$120, Web: \$1200 and up	Web version	PE version	no	no
Visible Light Onstage DVD Sonic eDVD (InterActual engine, feature of Sonic products)	\$500 and up	ActiveX version	ActiveX version	ActiveX version	Director version
Sonic DVD Presenter (InterActual engine, no longer available)	\$4000	yes	no	no	no
	\$40	no	yes	no	no
Tabuleiro DirectMediaXtra	\$200	no	no	no	MPEG-2/VOB files, but not DVD-Video volumes
LBO Xtra DVD	\$500?	no	no	no	yes
Matinée Presenter	?	Separate presentation application. Plays MPEG-2 files (not DVD-Video).			

Of course, if you simply treat DVD-ROM as a bigger, faster CD-ROM, you can create projects using traditional tools (Director, Flash, Toolbook, HyperCard, VB, HTML, etc.) and traditional media types (CinePak, Sorenson, Indeo, Windows Media, etc. in QuickTime or AVI format) and they'll work just fine from DVD. You can even raise the data rate for bigger or better quality video. But it usually won't look as good as MPEG-2.

[4.10] What are .IFO, .VOB, and .AOB files? How can I play them?

The DVD-Video and DVD-Audio specifications (see [6.1](#)) define how audio and video data are stored in specialized files. The .IFO files contain menus and other information about the video and audio. The .BUP files are backup copies of the .IFO files. The .VOB files (for DVD-Video) and .AOB files (for DVD-Audio) are MPEG-2 program streams with additional packets containing navigation and search information.

Since a .VOB file is just a specialized MPEG-2 file, most MPEG-2 decoders and players can play them. You may need to change the extension from .VOB to .MPG. However, any special features such as angles or branching will cause strange effects. The best way to play a .VOB file is to use a DVD player application to play the entire volume (or to open the VIDEO_TS.IFO file), since this will make sure all the DVD-Video features are used properly.

Many DVDs are encrypted, which means the .VOB files won't play when copied to your hard drive. See [4.5](#).

If you try to copy the .IFO and .VOB files to a recordable DVD it may not play. See [5.9](#).

You may also run into .VRO files created by DVD video recorders using the -VR format. In some cases you can treat the files just like .VOB files, but in other cases they are fragmented and unplayable. You'll need a utility such as [Heuris](#) Extractor to copy them to a hard disk in usable format.

[4.11] How do I get the Microsoft Windows DVD player application to run?

Windows 98 and Windows 2000 included a simple player application. It requires that a DirectShow-compatible DVD decoder be installed (see [4.1](#)). During setup, Windows installs the player application if it finds a compatible hardware decoder. You must install the player by hand if you want to use it with a software decoder or an unrecognized hardware decoder. Using WinZip or other utility that can extract from cab files, extract dvdplay.exe from driver17.cab (on the original Windows disc). This is the only file you need, but you can also extract the help file from driver11.cab, and you can extract dvdrgn.exe from driver17.cab if you intend to change the drive region.)

Windows Me includes a much improved player, although it still requires a third-party DirectShow-compatible decoder. Windows ME DVD Player is always installed, but it usually does not appear in the Start menu. To use the player, choose Run... from the Start menu, then enter dvdplay.

Windows XP moved DVD playback into Windows Media Player. It requires a DVD Decoder Pack (which contains a DirectShow-compatible DVD decoder). See Microsoft's [DVD Support in Windows XP](#) page for more info and links to Decoder Packs. Microsoft also has a list of [supported software decoders](#) for Windows XP.

[4.12] I upgraded to Windows XP, why did my DVD software stop working?

DVD player software written for Windows 98 and ME does not work in Windows XP. Most Windows 2000 software also requires an upgrade. Check with your DVD software manufacturer or your PC manufacturer for an upgrade, which in many cases is free. Or you may want to buy a low-cost Windows XP DVD Decoder Pack (see [4.11](#)).

[4.13] How can I rip audio from a DVD to play as MP3 or burn to a CD?

Keep in mind that unless you are copying something for your own personal use from a DVD that you own, copying a DVD is usually a copyright violation, which is illegal and dishonest.

Use a DVD ripping tool (see [4.8](#) and [6.4.2](#)) to extract Dolby Digital or PCM (WAV) files from a DVD. Then use a utility to convert to MP3, WMA, or other formats, or to burn to an audio CD.

Alternatively you can connect the audio output from a DVD player (see [3.1](#)) to an audio recorder or to audio inputs on a computer.

[5] DVD production

DVD production has two basic phases: *development* and *publishing*. Development is different for DVD-ROM and DVD-Video, publishing is essentially the same for both. Cheap, low-volume productions can be *duplicated* on recordable discs, whereas high-volume, mass-market products such as movies must be *replicated* in specialized factories.

DVD-ROM content can be developed with traditional software development tools such as Macromedia Director, Visual BASIC, Quark mTropolis, and C++. Discs, including DVD-R check discs, can be created with UDF formatting software (see [5.3](#)). DVD-ROMs that take advantage of DVD-Video's MPEG-2 video and multichannel Dolby Digital or MPEG-2 audio require video and audio encoding (see [5.3](#)).

DVD-Video content development has three basic parts: *encoding*, *authoring* (design, layout, and testing), and *premastering* (formatting a disc image). The entire development process is sometimes referred to as authoring. Development facilities are provided by many service bureaus (see [5.5](#)). If you intend to produce numerous DVD-Video titles (or you want to set up a service bureau), you may want to invest in encoding and authoring systems (see [5.3](#) and [5.4](#)).

Replication (including mastering) is the process of *pressing* discs in production lines that spit out a new disc every few seconds. Replication is done by large plants (see [5.5](#) for a list) that also replicate CDs. DVD

replication equipment typically costs millions of dollars. A variety of machines are used to create a glass master, create metal stamping masters, stamp substrates in hydraulic molds, apply reflective layers, bond substrates together, print labels, and insert discs in packages. Most replication plants provide *one-off* or *check disc* services, where one to a hundred discs are made for testing before mass duplication. Unlike DVD-ROM mastering, DVD-Video mastering may include an additional step for CSS encryption, Macrovision, and regionalization. There is more information on mastering and replication at [Technicolor](#) and [Disctronics](#).

For projects requiring fewer than 50 copies, it can be cheaper to use recordable discs (see [4.3](#)). Automated machines can feed recordable blanks into a recorder, and even print labels on each disc. This is called *duplication*, as distinguished from replication.

[5.1] How much does it cost to produce a DVD? Isn't it more expensive than videotape, laserdisc, and CD-ROM?

Videotape, laserdisc, and CD-ROM can't be compared to DVD in a straightforward manner. There are basically three stages of costs: production, pre-mastering (authoring, encoding, and formatting), and mastering/replication.

DVD video production costs are not much higher than for VHS and similar video formats unless extra features of DVD such as multiple sound tracks, camera angles, seamless branching, etc. are employed.

Authoring and pre-mastering costs are proportionately the most expensive part of DVD. Video and audio must be encoded, menus and control information have to be authored and encoded, it all has to be multiplexed into a single data stream, and finally encoded in low level format. Typical charges for compression are \$50/min for video, \$20/min for audio, \$6/min for subtitles, plus formatting and testing at about \$30/min. A ballpark cost for producing a Hollywood-quality two-hour DVD movie with motion menus, multiple audio tracks, subtitles, trailers, and a few info screens is about \$20,000. Alternatively, many facilities charge for time, at rates of around \$300/hour. A simple two-hour DVD-Video title with menus and various video clips can cost as low as \$2,000. If you want to do it yourself, authoring and encoding systems can be purchased at prices from \$50 to over \$2 million. See [5.8](#) for more on low-cost DVD creation.

Videotapes don't really have a mastering cost, and they run about \$2.40 for replication. CDs cost about \$1,000 to master and \$0.50 to replicate. Laserdiscs cost about \$3,000 to master and about \$8 to replicate. As of 2003, DVDs cost about \$1000 to master and about \$0.70 to replicate. Double-sided or dual-layer discs cost about \$0.30 more to replicate, since all that's required is stamping data on the second substrate (and using transparent glue for dual layers). Double-sided, dual-layer discs (DVD-18s) are more difficult and more expensive (see [3.3.1](#)).

[5.2] What DVD-ROM formatting tools are available?

- [Ahead](#)
 - *Nero*. DVD formatting software for Windows. Can make disc image files and bootable discs. \$70.
- [GEAR](#)
 - *GEAR Pro DVD*. DVD formatting software for Windows 95/98/NT4. Writes to DVD-R, DVD-RAM, jukeboxes, and tape, along with general UDF formatting and CD-R/RW burning features. \$700.
- [JVC Professional Computer Products](#)
 - *DVD RomMaker*. DVD formatting systems with RAID hardware. \$60,000 to \$100,000.
- [Philips](#)
 - *DVD-ROM Disc Builder*. DVD formatting software for Windows NT. Writes to tape. (Seems to be discontinued.)
- [Pinnacle](#)
 - *InstantCD/DVD*. Software tools for recording files to CD-R/W, DVD-RAM and DVD-R/W discs from Windows. Can make a bootable DVD. \$50.

- *InstantCopy*. CD/DVD copy software for Windows. \$30.
- [Roxio](#)
 - *Toast DVD*. DVD formatting software for Mac OS. Writes to DVD-R and tape. Can create DVD-Video discs from VOB and IFO files. \$200
- [SmartDisk](#) (acquired MTC)
 - *ForDVD*. DVD formatting software for Windows. Writes to DVD-R and tape. Can create DVD-Video discs from VOB and IFO files. \$1200.
- [Smart Storage](#)
 - *SmartDVD Maker*. DVD formatting software for Windows NT. Writes to DVD-R and tape. Can create DVD-Video discs from VOB and IFO files. \$2500. (Discontinued as of March 2001.)
- [Software Architects](#)
 - *WriteDVD Pro* and *WriteUDF*. DVD formatting software for Mac OS and Windows. Writes to DVD-R and DVD-RAM.
- [Sonic](#) (acquired Daikin and Veritas DMD)
 - *DVD-ROM Formatter*. DVD formatting software for Windows NT/2000/XP. Writes to DVD-R and tape. Can create DVD-Video discs from VOB and IFO files.
 - *RecordNow* and *RecordNow MAX Platinum*. CD and DVD burning software for music, photos, and video. Windows. \$50 and \$80.
 - *Backup MyPC* and *Simple Backup*. Windows file backup software for recordable DVD and CD.
- Veritas (acquired Prassi)

Note: Veritas Desktop and Mobile Division was acquired by Sonic in November 2002.
- VOB

Note: VOB was acquired by Pinnacle Systems in October 2002.
- [Young Minds](#)
 - *DVD Studio* and *MakeDisc for DVD*. DVD formatting software for Windows NT and Unix. Writes to DVD-R.

Features to look for in DVD formatters:

- Support for UDF file system, including MicroUDF (UDF 1.02 Appendix 6.9) for DVD-Video and DVD-Audio zones.
- Support for UDF bridge format, which stores both UDF and ISO-9660 file systems on the disc.
- Ability to recognize VIDEO_TS and AUDIO_TS directories (containing IFO, VOB, and AOB files) and place them contiguously at the physical beginning of the disc for compatibility with DVD-Video players. Placement of directory entries in first UDF file descriptor is also needed for compatibility with certain deficient consumer players.
- Support for long filenames in Windows (Joliet format recommended).
- Full equivalence between UDF and Joliet (ISO-9660) filenames. (Windows NT 4.0 and Windows 98 read Joliet filenames; Mac OS 8.1+, Windows 98, and Windows 2000 read UDF filenames. MS-DOS and Windows 95 and earlier read ISO-9660 filenames. Mac OS 8.0 and earlier read HFS or ISO-9660 filenames.)
- Proper truncation and translation of ISO-9660 filenames to 8.3 format for discs intended for use with MS-DOS and certain other OSes.
- Support for Mac OS file information within the UDF file system (for use with Mac OS 8.1 and later).

- Support for Mac OS HFS file system if icons and other file information is needed for Mac OS versions earlier than 8.1.
- Ability to create a bootable disc using the [El Torito](#) specification in the ISO-9660 sectors.

[5.3] What DVD production tools are available?

[5.3.1] Video encoding tools

- [Brent Beyeler](#)
 - *bbMPEG*. Basic MPEG-2 encoder for Windows. Free from various download sites.
- [Canopus](#)
 - *ProCoder*. Software video format converter with MPEG encoding. Two-pass VBR. Advanced features such as NTSC<->PAL conversion, deinterlacing, 2-3 pulldown, and batch processing. Windows. \$700.
 - *MVR1000*. Hardware real-time video capture and MPEG encoder board for Windows. VBR and CBR. Includes Sonic *DVDit SE* for DVD/VCD authoring.
 - *Amber*. MPEG-2 hardware designed for encoding and archiving video in MPEG format. VBR and CBR. (Panasonic MN85560 encoder chip). Windows. \$2,000.
 - *DVRaptor RT*. Hardware DV video editing with MPEG output. Windows. \$600.
 - *DVStorm*. Hardware video editing/encoding system for MPEG and DV. Includes Ulead *DVD Workshop* for DVD/VCD authoring. Windows. \$1,100.
 - *DVRex RT Professional*. Hardware video editing/encoding system for MPEG and DV. Includes Sonic *DVDit SE* for DVD/VCD authoring. Windows. \$4,400.
- [Custom Technology](#)
 - *Cinemacraft Encoder-PRO*. MPEG-2 real-time NTSC video encoding software for Windows NT. \$38,000.
 - *Cinema Craft Encoder-SP*. MPEG video encoding software for Windows XP and 2000. CBR and VBR. \$2,000 .
 - *Cinema Craft Encoder-Basic*. MPEG video encoding software for Windows. CBR and VBR. \$60 .
- [Darim](#)
 - MPEGator 2. MPEG-2 real-time encoding hardware for Windows and Windows NT. \$1,800.
- [Dazzle](#)
 - *Digital Video Creator II*. MPEG-2 video capture/edit/encode system with PCI card. Includes Sonic *DVDit LE*. Windows 98/2000. \$300.
- [Digital Ventures](#)
 - *DVDComposer*. MPEG-2 video encoding system for SGI. VBR and CBR. (C-Cube chip). \$50,000.
- [Digital Vision](#)
 - *BitPack*. MPEG-2 video encoding workstation. Extendable to HDTV.
 - DVNR system for video pre-processing.
- [Digigami](#)
 - *MegaPeg*. MPEG-2 video encoding software for Windows. VBR and CBR. \$500. Also available as Adobe Premiere plug-in for Windows or PowerMac. \$400.

- [DV Studio](#)
 - *Apollo Expert*. MPEG-2 video encoding (and decoding) hardware for Windows NT. \$2,000.
- [FlaskMPEG](#)
 - Freeware encoding software for Windows.
- [Gunjarm Digital/Metaware](#) (formerly Gunzameory and DreamCom)
 - *MPEGRich*. Professional MPEG-2 real-time encoding hardware. CBR and VBR. Windows NT.
- [Heuris](#)
 - *MPEG Power Professional 1, MPEG Power Professional 2, MPEG Power Professional DVD, MPEG Power Professional DTV-SD, and Power Professional DTV-HD*. MPEG-2 video encoding software for Mac OS and Windows. DVD and DTV versions include VBR encoding. \$350, \$1,000, \$1,500 and \$2,500.
 - *Cyclone*. MPEG-1 and MPEG-2 encoding software designed for OEMs. Mac OS and Windows NT.
- [Ligos](#)
 - *LSX-MPEG Encoder*. MPEG-2 video encoding software. CBR and VBR. Windows. \$150.
 - *LSX-MPEG Suite*. Adobe Premiere plug-in for producing MPEG-1 or MPEG-2 output. Includes standalone LSX-MPEG player. Windows 9x/NT. \$400.
- [Media100](#)
 - *iFinish RealTime MPEG Option*. Editing software with MPEG-2 video encoding add-on. Windows NT. \$6,000 to \$18,000.
- [Microcosmos/Nanocosmos](#)
 - *MPEG SoftEngine*. MPEG-2 video encoding software for Windows, Solaris, and Linux. \$250 to \$3500.
- [Minerva](#)
 - *Compressionist 110, 200, and 250*. Professional MPEG-2 real-time encoding hardware. CBR and VBR. Mac OS host computer. \$70,000. [No longer available.]
 - *Publisher 300*. Professional MPEG-2 video and MPEG Layer 2 audio real-time encoding hardware. CBR and VBR. Mac OS. [No longer available.]
- [Optibase](#)
 - *MPEG MovieMaker 200*. Professional MPEG-2 video and Dolby Digital audio real-time encoding hardware for Windows and Windows NT. CBR and VBR. \$7,000 to \$22,000.
- [Pegasys](#)
 - *TMPGEnc* and *TMPGEnc Plus*. MPEG-1 and MPEG-2 software video encoders, plus multiplexing/demultiplexing, file joining, and trimming tools. Basic version is free; Plus version is \$48 to download, \$88 in retail box.
- [Philips](#)
 - *DVS3110*. Professional MPEG-2 video encoder for PAL and NTSC. CBR and VBR.
- [PixelTools](#)
 - *Expert-DVD*. MPEG-2 video encoding software. CBR and VBR. Windows. \$2,000.
 - *Expert-2*. Professional, tweakable MPEG encoder. Windows.
- [Snell & Wilcox](#)

- *Prefix CPP100, Prefix CPP200, NRS500, Kudos NRS50, and Kudos NRS30..* Video preprocessors (noise reduction and image enhancement).
- [Sonic Solutions](#)
 - *SD-1000.* Professional MPEG-2 video encoding hardware. CBR and VBR. Segment-based reencoding. Mac OS and Windows OS. \$13,000.
 - *DVD Fusion.* Encoding/authoring plug-in for Media 100 and QuickTime video editing systems. Hardware-accelerated version (velocity engine) encodes VBR and CBR in real time. Mac OS. \$8,000 and \$12,000.
- [Sony](#)
 - *DVA-V1100.* High-end MPEG-2 video encoding hardware. CBR and VBR. Windows NT.
- [Spruce Technologies](#)

Note: Spruce was acquired in July 2001 by Apple. The MPX-3000 encoder is still available from some dealers.

 - *MPX-3000.* Professional MPEG-2 real-time encoding hardware. CBR and VBR. Windows NT.
 - *MPEGXpress 2000* (formerly from CagEnt). Professional MPEG-2 real-time encoding hardware. CBR and VBR. Windows NT.
- [VisionTech](#)
 - *MVCast.* Low-end real-time MPEG-2 video/audio encoding hardware for Windows NT and Solaris. AVI-to-MPEG-2 conversion. \$2000.
- [Vitech](#)
 - *MPEG Toolbox-2.* AVI to MPEG-2 VBR/CBR. MPEG-2 video editing. Windows 95/98/NT. \$250.
- [Wired](#)
 - *MediaPress.* MPEG-2 encoding hardware (PCI). CBR and VBR. Mac OS and Windows 95/98/NT. \$2,500.
- [Yusuf Motiwala](#)
 - *YMPEG.* Basic MPEG-1 and MPEG-2 plug-in software encoder for Windows. Also does KVCD. Free.
- [Zapex](#)
 - *ZP-200.* Real-time PCI encoder for MPEG-2 video and PCM Audio. Non-real-time encoding and VOB multiplexing from Adobe Premiere. Windows NT.
 - *ZP-300.* Real-time PCI Encoder for CBR/VBR MPEG-2 video, 2-channel Dolby Digital, and PCM Audio. Non-real-time encoding and VOB multiplexing from Adobe Premiere. Windows NT.

[5.3.2] Audio encoding tools

- Astarte

Note: Astarte was acquired in April 2000 by Apple.
- [Digital Vision](#)
 - *BitPack.* Multichannel audio encoding workstation for Dolby Digital, MPEG-2, and PCM.
- [Dolby](#)
 - *DP569.* Multichannel Dolby Digital audio encoding hardware.
- [Kind of Loud Technologies](#)

- *SmartCode Pro/Dolby Digital*. 5.1-channel encoding software plugin for Digidesign Pro Tools. \$1000.
 - *SmartCode Pro/DTS*. 5.1-channel encoding software plugin for Digidesign Pro Tools. \$2000.
- [Microcosmos](#)
 - *MPEG SoftEngine/Audio*. MPEG audio encoding software for Windows/Solaris. \$95/\$350.
- [Minerva](#)
 - *Audio Compressionist*. Professional Dolby Digital real-time, 5.1-channel encoder. Windows NT.
- [Minnetonka Audio Software](#)
 - *SurCode for DOLby Digital*. Multichannel Dolby Digital audio encoding software. \$1000.
 - *SurCode DVD Professional for DTS*. Multichannel DTS audio encoding software. \$2000.
- [Philips](#)
 - *DVD3310*. Professional MPEG-2 multichannel audio encoder.
- [PixelTools](#)
 - *Expert-Audio*. MPEG Layer 2 audio encoding software. Windows.
- [Sonic Solutions](#)
 - *Sonic DVD Studio*. Professional real-time Dolby Digital 5.1, MPEG-2, and PCM audio encoding hardware. Mac OS.
 - *MLP Encoder*. \$9,000.
- [Sonic Foundry](#)
 - *Soft Encode*. Dolby Digital 2-channel or 5.1-channel audio encoding software. Windows 95/98/NT. \$500 (2 channels) or \$900 (5.1 channels).
- [Sony](#)
 - *DVA-A1100*. High-end, real-time Dolby Digital 5.1, MPEG-2, and PCM audio encoding hardware. Windows NT.
- [Spruce Technologies](#)

Note: Spruce was acquired in July 2001 by Apple. The ACX-5100 encoder is still available from some dealers.

 - *ACX- 5100* (formerly from CagEnt). Professional Dolby Digital real-time, 5.1-channel encoder. Windows NT.
 - *ACX-2000* (formerly from CagEnt). Professional Dolby Digital real-time, 2-channel encoder. Windows NT.
- [Zapex](#)
 - *ZP-100*. Real-time PCI encoder for 2- or 5.1-channel Dolby Digital and MPEG Layer 2. Windows NT.

[5.3.3] Other production tools

- [Alcohol Software](#)
 - *Alcohol 52%*. Emulate CDs and DVDs without physical disc. Windows. \$28.
 - *Alcohol 68%*. Copy CDs and DVDs. Windows. \$30.
 - *Alcohol 120%*. Combination of *Alcohol 52%* and *Alcohol 68%*. Windows. \$50.

- [ASINT](#)
 - Industrial DVD players, touchscreens, and DVD kiosk products.
- [BCD Associates](#)
 - DVD controllers for custom installations.
- [Cambridge Multimedia](#)
 - Touchscreens and other custom interfaces for industrial DVD players.
- [Computer Prompting & Captioning Co.](#)
 - *CPC-DVD*. Closed Caption production system. DOS. \$6,000.
- [DCA \(Doug Carson & Associates\)](#)
 - *MIS (Mastering Interface System)*. Mastering interface system for DVD and CD. Windows NT.
 - *ITS (Image Transfer System)*. Transfer and convert DVD and CD images.
 - *DVS+ (Data Verification System)*. Checks DVD and CD images. Includes *Interra Surveyor* to check for DVD-Video spec compliance. Can transfer between discs and tape. Windows NT.
 - *INMS (Integrated Network Mastering System)*. Combination of MIS, ITS, DVS+ in a system with a RAID.
- [Eclipse Data Technologies](#)
 - *EclipseSuite*. DVD and CD premastering tools to copy and verify images, copy tapes, etc. Windows NT.
 - *ImageEncoder*. LBR mastering interface for CD and DVD mastering. Windows NT.
- [FAB](#)
 - FAB Subtitler DVD Edition. Subtitle generator program (text and bitmap formats) that works with most DVD authoring systems. Windows.
- [Heuris](#)
 - Xtractor. Software to extract video and audio streams from unencrypted DVD-Video discs and DVD-VR discs. \$150.
- [Isomedia](#)
 - DVD DLT utilities: copy DLTs, extract images, inspect ISO/UDF/DDP info, checksums, etc.
- [Museum Technology Source](#)
 - DVD controllers for Pioneer industrial players in custom installations.
- [Novastor](#)
 - *TapeCopy*. Copy DLTs, inspect tape blocks.
- [PixelTools](#)
 - *MPEGRepair*. Software to analyze, repair, insert Closed Captions, add panscan vectors, and do other handy things to MPEG files. Windows.
- [Smart Projects](#)
 - *ISO Buster*. Inspect CD and DVD volumes and image files. Freeware/shareware (\$26).
- [SoftNI](#)

- *The DVD Subtiter*. Subtitle graphics preparation software. Windows 95/98/NT/2000.
- *The Caption Encoder*. Closed Caption production system. DOS, Windows 95/98.
- *The Caption Retriever*. Closed Caption recovery and decoding system. Windows 95/98/NT/2000.
- [Tapedisk](#)
 - *TD Raw*. Reads raw data from a SCSI tape drive as if it were a hard disk. DOS/Windows. \$500.
 - *TD RAW NT*. Version of TD Raw for Windows NT 4.0. \$750.
- [Technovision](#)
 - Touchscreens and other custom interfaces for industrial DVD players.
- [Teco](#)
 - *ParseMPEG* (\$500) and *Bitrate Viewer* (free). Software to analyze MPEG streams. Windows.

Also see [5.6](#) for DVD emulation, verification, and analysis tools.

[5.3.4] Other production services

- [Captions, Inc.](#) (Burbank, CA), 818-729-9501. Captioning and subtitle services.
- [European Captioning Institute \(ECI\)](#) (London, UK). +44 (0)20 7323 4657. Captioning and subtitle services.
- [Captioneering](#) (Burbank, CA), 888-418-4782. Captioning and subtitle services.
- [National Captioning Institute](#) (NCI) (LA 818-238-4201; NY 212-557-7011; VA 703-917-7619). Captioning and subtitle services.
- [SDI Media Group](#) (worldwide), +44 (0)20 7349. Subtitle services.
- [Softtiter](#) (Los Angeles, CA). Subtitle services.
- [Tele-Cine](#) (London, UK), +44 (0) 171 208 2200. Film-to-video conversion.
- [TelecineMojo](#) (Los Angeles, CA), 323-697-0695. Film-to-video conversion.
- [Vitac](#) (Canonsburg, PA) 888-528-4822. Captioning services.

[5.4] What DVD authoring systems are available?

For more detail on the systems listed below, follow the links or see the comparison table of selected DVD authoring systems at [DVDirect](#).

- [Apple](#)
 - *DVD Studio Pro*. Mid-level DVD-Video authoring tool for Mac OS. \$1,000.
 - *iDVD*. Simple, drag-and-drop DVD-Video authoring, bundled with Macs that have DVD-R drives.
 - *DVDMaestro*. Windows. See Spruce, below.
- Astarte

Note: Astarte was acquired in April 2000 by Apple, so their products are generally no longer available, although they resurfaced in March 2001 as iDVD and DVD Studio Pro from Apple.

 - *DVDirector* and *DVDirector Pro*. Low-end and mid-level DVD-Video authoring tools for Mac OS. Pro version includes *MediaPress* hardware MPEG-2 encoder from [Wired](#). *Millennium Bundle* turnkey workstation includes *DVDirector Pro*, Mac G4, and more. \$5,400, \$10,00, \$15,000.

- *VDVDelight*. Simple, drag-and-drop DVD-Video authoring for Mac OS. \$1,000.
- *VDVExport*. Software to convert Macromedia Director presentations to DVD-Video format. Mac OS. \$900.
- [Authoringware](#)
 - *DVD WISE*. Mid-level authoring system for Windows 95/98/NT. \$950.
 - *DVD Quickbuilder*. Multiplexing software.
- [Avid](#)
 - *Xpress DV*. Video editing software with DVD-Video output (using Sonic AuthorScript). \$1,700.
 - *Xpress DV Powerpack*. *Xpress DV* with other software, including Sonic DVDit SE. \$3,000.
- [Blossom Technologies](#)
 - *DaViD 2000, 4000, 6000, and 10000*. Turnkey Windows NT 4.0 systems using Daikin *Scenarist* authoring software and Optibase encoding hardware or Sonic Foundry audio encoding software. \$20,000 to \$100,000.
- [Canopus](#)
 - *Amber for DVD*. Amber MPEG-2 encoding hardware with Spruce *DVDVirtuoso* authoring software. \$3,300.
- Daikin (Daikin US Comtec Laboratories)
Note: Daikin's DVD business was acquired by Sonic in February 2001. Scenarist, ReelDVD, and ROM Formatter are now carried by Sonic.
- [DreamCom](#) (formerly Gunzameory)
 - *DVDRich*. Mid-level DVD-Video authoring/encoding on Windows NT. Uses MPEGRich encoder and Daikin *Scenarist* or Intec *DVDAuthorQuick*. \$30,000.
- [DV Studio](#)
 - *Apollo Expert Author* and *Apollo Expert DVDer*. Mid-level DVD-Video authoring system for Windows NT, using DV Studio *Apollo Expert* MPEG-2 encoding hardware and Intec *DVDAuthorQuick* authoring software (*Author* package, \$4,000) or Sonic *DVDit* (*DVDer* package, \$2,500).
 - *Apollo Expert Archiver*. MPEG-2 encoding system for archiving video to DVD-RAM. \$2,500 (DVD-RAM drive included).
- [Futuretel](#)
 - *Crescendo*.
- [Houpert Digital Audio](#) (HDA)
 - *CubeDVD-A*. DVD-Audio authoring plug-in module for Cube-Tec AudioCube digital audio workstation. Uses audio assets mastered by NuendoCube. Windows 2000.
- [InnovaCom](#)
 - *DVDImpact*. DVD-Video authoring aimed at multimedia studios and corporations. Uses InnovaCom *DV5100* hardware encoding station and Daikin *Scenarist NT* or Intec *DVDAuthorQuick* software. \$47,500 and \$29,000.
- [Intec America](#)
 - *DVDAuthorQuick*. Mid-level and low-level DVD-Video authoring software line for Windows NT. Comes in three versions: *Pro*, *Desktop*, and *LE*. \$8,000, \$2,500, and \$400.

- [Margi Systems](#)
 - *DVPublish-to-Go*. Simple DVD authoring to DVD-R or CD-R/W. Includes Margi's *1394-to-Go* PC, MGI's *VideoWave III*, and Sonic Solution's *DVDit LETx*. Windows 98 SE or 2000. \$300.
- [Matrox](#)
 - *Matrox RT2000* and *DigiSuite DTV*. Video capture and editing in DV and MPEG-2 formats. Includes Sonic Solution's *DVDit LE* for simple DVD authoring. Windows 98. \$1,300.
- [Mediachance](#)
 - *DVD-lab*. DVD-Video authoring software with some unique features. Windows. \$100.
- [Microboards](#)
 - *DVD AuthorSuite*. DVD-Video authoring/encoding for Windows NT. Uses Intec *DVDAuthorQuick* software, Zapex encoders, and Sigma Designs decoder. \$25,000.
- [Minerva](#)

Note: Minerva DVD authoring software was acquired by Pinnacle in 2000, so it is no longer generally available. Impression was re-released by Pinnacle in July 2001.

 - *DVD-Professional SL* and *DVD-Professional XL*. DVD-Video authoring/encoding systems for Windows NT. Includes Publisher 300 and Minerva Studio. \$100,000.
 - *Impression*. DVD-Video authoring/encoding system for Windows. \$10,000.
- [Minnetonka Audio Software](#)
 - *DiscWelder Steel*. Basic DVD-Audio authoring software. Windows. \$500.
 - *A-Plus*. Basic DVD-Audio authoring software. Windows. \$2,000.
 - *DiscWelder Chrome*. Professional DVD-Audio authoring software. Windows. \$3500.
- MTC (Multimedia Technology Center)

Note: MTC was acquired by SmartDisk in 2000.

 - *StreamWeaver Express* and *StreamWeaver Pro*. Simple and mid-level DVD-Video authoring, and \$900 premastering on Windows. \$900 and \$3,000.
 - *DVDMotion*. Authoring systems for Windows, oriented toward multimedia DVD-ROM production. Comes in three versions: *Pro*, *SE* (Standard), *CE* (Consumer). \$1,000, \$400, \$95.
 - *DVDMotion CE*. Entry-level authoring system for Windows 98/NT4. \$75.
- [NEC](#)
 - *DV Editor*. IEEE-1394 card and software, plus Sonic's *DVDit LE*. Windows 98. Available in Japan only.
- [Optibase](#)
 - *DVD-Fab XPress* and *DVD-Fab*. Turnkey DVD-Video authoring/encoding systems for Windows NT. Includes Optibase *MPEG Fusion* MPEG-2 encoder and Daikin *Scenarist* authoring software. \$35,000.
- [Panasonic](#)
 - *LQ-VD2000S*. Turnkey professional DVD-Video authoring system, including Windows NT 4.0 workstation. Uses Panasonic MPEG-2 encoder and *LQ-VD3000* emulator. \$120,000.
 - *LQ-VDS120*. Additional workstation software for networking with *LQ-VD2000S*. \$22,550
 - *LQ-VD3000*. DVD Emulator. \$15,000

- [Pegasys](#)
 - *TMPEnc DVD Author*. Basic DVD-Video authoring for Windows. \$68.
- [Pinnacle](#)
 - *DVD1000*. MPEG-2 video editing and DVD-Video authoring system for Windows. Pinnacle DVD1000 hardware with Adobe Premiere and Minerva Impression. \$8,000.
 - *Impression DVD*. Mid-level DVD-Video authoring/encoding system for Windows. \$1,000.
 - *Pinnacle Pro-ONE*. DVD editing/authoring package. Uses Adobe *Premiere* and *Impression DVD-SE*. \$1,300.
 - *Pinnacle Edition*. Video editing with linear-play DVD/SVCD output. \$700.
- [Philips](#)
 - *DVD-Video Disc Designer* and *DVD-Video Authoring Toolset*. Windows NT.
- [Pioneer](#)
 - *DVDDesigner*. An off-line design tool for DVD-Video planning and layout. Can feed an "authoring decision list" into other authoring systems. Available free to qualified developers. Windows and Mac OS.
- [PixelTools](#)
 - *SimpleDVD*. AVI-to-DVD converter for Windows. \$1,500.
 - *HDTVPlug-in*. Simple encoding/authoring plug-in for Adobe Premiere. Generates single-program, autoplay images that can be copied to recordable discs. \$1,000.
- Q-Comm
 - *EasyDVD*.
- [Roxio](#)
 - *Easy CD & DVD Creator*. Basic DVD-Video and VCD authoring for Windows. \$80.
- [SADiE](#)
 - *DVD-A Direct*. DVD-Audio authoring package for SADiE editing and mastering system. Windows.
- [Sonic Solutions](#)
 - *Scenarist SGI*. DVD-Video authoring for SGI. The original professional system. \$25,000.
 - *Scenarist NT*. Professional DVD-Video authoring on Windows NT. Comes in two versions: *Advanced*, \$15,000; *Professional*, \$22,000.
 - *DVD Creator*. Professional DVD-Video authoring/encoding systems for corporate and industrial applications. Mac OS. Various configurations: *DVD Creator All-in-One Workstation*, \$80,000; *DVD Creator Encoding*, \$24,500, *DVD Creator Authoring*, \$15,000.
 - *DVD-Audio Creator*. DVD-Audio authoring system (co-developed with Panasonic). Windows. *DVD-Audio Complete Workgroup*, \$53,000; *DVD-Audio Creator*, \$13,000; *DVD-Audio Creator LE*, \$6,000.
 - *OneClick DVD*. Simple DVD-Audio authoring. Mac OS. \$15,000.
 - *DVD Fusion*. Mid-level DVD-Video authoring system. Mac OS.
 - *DVD Producer* (formerly *DVD Fusion for Windows*). Mid-level DVD-Video authoring system. Windows. \$3,000.
 - *ReelDVD*. Low-end authoring for NT and Windows 2000. \$1,500.

- *DVDIt LE* (limited), *SE* (standard), and *PE* (professional). Basic DVD-Video authoring for Windows. \$300 (SE), \$400 (PE). *LE* version is designed to be bundled with other hardware and software products.
- *MyDVD*. Simple personal DVD-Video authoring for Windows. \$80. Generally bundled with DVD recorders.
- PrimeTime. Addition to Windows XP Media Center Edition for burning recorded TV shows to DVD. \$80.
- [Sony Media Software](#)
 - *Vegas+DVD*. Mid-level authoring toolset (*DVD Architect*) bundled with video editing software. \$1,000.
- [Sony Professional](#)
 - *DVA-1100*. High-end authoring/encoding system with one to eight stations. Price range starts at \$175,000.
- Spruce Technologies

Note: Spruce was acquired in July 2001 by Apple. DVDMaestro is still available from some dealers.

 - *DVDMaestro*. High-end authoring/encoding systems for Windows NT. \$25,000.
 - *DVDConductor*, *DVDVirtuoso*, *DVDPerformer*. Mid-level authoring/encoding systems for Windows NT. Also allow DVD content to be recorded and played from CD-R. \$10,000, \$1500, \$?.
 - *SpruceUp*. Simple personal DVD-Video authoring for Windows (NT4/98/ME/NT/2000). \$129.
 - *DVDStationCX*. Turnkey system using DVDConductor. \$25,000.
 - *DVDStationNLE*. Turnkey system using DVDConductor and Heuris *MPEG Power Professional* encoding software. \$10,000.
 - *DVDTransfer*. Turnkey automated tape-to-DVD system. \$30,000.
- [Ulead](#)
 - *MediaStudio Director's Cut*. Video editing software with built-in DVD authoring. \$190.
 - *DVD Workshop*. Basic video editing and DVD authoring. \$300.
- [Visible Light](#)
 - *Macarena* and *Macarena Pro*. DVD-Video authoring for Power Mac G4. Software encoding or hardware encoding (Pro version). Uses Astarte *DVDirector* software. \$10,000 and \$15,000.
- [Vitech](#)
 - *DVD Toolbox*. AVI to DVD-Video. Write to CD-R, DVD-R, DVD-RAM, etc. Windows 95/98/NT. \$400.
 - *DVD Cut Machine*. Hardware audio/video encoder bundled with DVD Toolbox software. \$800.

[5.5] Who can produce a DVD for me?

There are various steps to producing a DVD, but they can be split into two major parts: 1) authoring (creating the content and formatting a disc image), and 2) replication (cutting a master disc and stamping out hundreds or millions of copies). See [5](#) for more details.

[A] = authoring (including encoding, DVD-R creation, and premastering).

[R] = replication (mastering, check discs, and mass production).

[D] = duplication (short-run copying onto recordable discs)

Note that most replicators and duplicators have in-house authoring facilities or partnerships with authoring houses.

Other lists are available at [DVDInsider](#), [DVDMadeEasy](#), and [Post Magazine](#). Also see [5.8](#) for companies specializing in transferring home videos and slides to DVD.

- [A] [12CM Multimedia](#) (Mountain View, CA, 650-564-9000; Santa Clara, CA 408-350-9000).
- [A] [24-7DVD](#) (London, UK), +44 (0) 208 748 2247.
- [A] [Abbey Road Interactive](#) (London, UK), +44 171 266 7000.
- [A] [Accelerated Post](#) (Chicago, IL, 312-595-9100; Minneapolis, IN, 612-377-3100).
- [A] [Acutrack](#) (Pleasanton, CA), 888-234-3472.
- [A] [Advanced Media Post](#) (Burbank, CA), 818-973-1668.
- [A] [Advanced Visual Communications](#) (AVCOM Video) (Tampa, FL), 813-875-0888.
- [A] [Alchemey Digital Video](#) (Portland, OR), 503.735.1222.
- [A] All Post (CA), 818-556-5756.
- [A] [Aludra](#) (Ontario, Canada), 888-552-5837.
- [R] [Americ Disc](#) [also see MPO], Salida, CA, 888-545-7350; Miami, FL, 800-364-0759; Drummonville, Quebec, Canada, 800 263-0419.
- [A] [Artistic Communication Center](#) (Chicago, IL), 312-829-8100.
- [A] [Ascent Media](#) (Santa Monica, CA, 818-840-7235; Northvale, NJ, 201-784-2129; London, UK, +44 (0) 20 7208 1567). (Merger of companies including 4MC, Post Box, Stream, TVP, ToddAO, and POP)
- [A] [asv multimedia](#) (Mengen, Germany), +49 (0) 7572-78361.
- [A] [Atelier Digital](#) (Birmingham, AL), 205-263-7678.
- [A] [Audio Plus Video International](#) Northvale, NJ, 201-767-3800; Burbank, CA, 818-841-7100.
- [A] [AVCA](#) (Austin, TX), 512 472-4995.
- [A] [AVM Dialog AB](#) (Goteborg, Sweden).
- [A] [B1 Media](#) (Sherman Oaks, CA), 818-905-9902.
- [A] [BCD Associates](#) (Oklahoma City, OK), 405-843-4574.
- [A] [Blackcat Interactive](#) (Cheltenham, UK), +44 1926-614675.
- [A] [Blink Digital](#) (New York, NY), 212-661-6900.
- [A] [Blue City Digital](#) (North Kansas City, MO), 816-300-0441.
- [A] [C&C interactive AB](#) (Boras, Sweden), +46 33 290700.
- [A] [California DVD](#) (San Francisco, CA), 1-800-864-1957.
- [A] [Cambridge Multimedia](#) (Cambridge, UK), +44 (0) 1954 262030.
- [R] [Canada Disc & Tape](#) (Calgary, Canada), 403-277-9292.
- [A] [CAT Technologies](#) (London, UK), +44 (0)20 8332 6548.
- [A] [CBO Interactive](#) (Los Angeles, CA), 323-468-9580.
- [A] [CDA](#) (Albrechts, Germany), +49 (0) 36 81 / 3 87 - 1 53.
- [R] [CD Digital Card](#) (Rancho Cucamonga, CA), 800-268-1256 [specialize in shaped discs].
- [R] [CDman](#) (Vancouver, BC, Canada), 800-557-3347.

- [R] [CD Press](#) (Bergdietikon, Switzerland), +41 (0)1 745 90 60.
- [R] [CD-ROM-Works](#) (Portland, OR), 503-219-9331.
- [A] Chicago Recording Company (Chicago, IL), 312-822-9333.
- [R] [Cine Magnetics](#) (Armonk, NY, 914-273-7500; Studio City, CA, 818-623-2560), 800-431-1102.
- [A] [Cinram/POP DVD Center](#) (Santa Monica, CA).
- [R] [Cinram](#) (Huntsville, AL, 256-859-9042; Anaheim, CA, 714-630-6700; Richmond, IN, 800-865-2200; Scarborough, Ontario, Canada, 416-298-8190), 800-433-DISC.
- [A] [CKS|Pictures](#) (CA & NY), 408-342-5009.
- [A] [ComChoice](#) (Gardena, CA), 877-633-4241.
- [A] [Complete Post](#) (Hollywood, CA), 323-860-7622.
- [R] Concord Disc Manufacturing (Anaheim, CA) [Acquired 12/03 by Crest National]
- [A] [COTOC](#) (Stockholm, Sweden), +46 8 54568780.
- [A] [Crafted Timbre](#) (Cortland, NY) 607-756-4780.
- [A] [CREATIVVIDEO & DIALOGOS](#) (Moedling, Austria), +43(0)2236-48311.
- [R] [Crest National](#) (Hollywood, CA), 323-860-1300.
- [A] [CRUSH Digital Video](#) (NY), 212-989-6500.
- [A] [CruSh Interactive](#), (Houston, TX), 713-972-1133.
- [A] [Cubist Post & Effects](#) (Philadelphia, PA), 215-627-1292.
- [A] [CustomFlix](#) (San Luis Obispo, CA), (978) 626-1110.
- [A] [Cut & Copy](#) (Vienna, Austria), +43 1 523 98 24.
- [A] [CVC](#) (Los Angeles, CA), 818-972-0200. (Time Warner California Video Center)
- [A] [D2 Productions](#) (CA), 818-576-8113.
- [A] [Dallas Digital Transfer](#) (Dallas, TX), 214336-6292.
- [R] Davenport (Van Nuys, CA).
- [A] [DAVID](#) (Aprilia, Italy), 39-6-92704597.
- [R] [Deluxe Video Services](#) (Carson City, CA), 310-518-0710. (Formerly Pioneer Video Manufacturing)
- [R] Denon Digital [now MD Digital]
- [A] [Designlab Systems](#), (London, UK), +44 (0) 207 437 5621.
- [A] [Digidisc](#) (Atlanta, GA), 770-925-1839.
- [A] [Digisonics DVD](#) (Northridge, CA), 818-882-3444.
- [A] [Digital Farm](#) (Seattle, WA), 206-634-2677.
- [A] Digital Group (London, UK)
- [A] [digital images](#) (Halle, Germany), +49 (0)345/2175-101.
- [A] [Digital Media Group](#) (Amsterdam, The Netherlands), +31-20-422-6317.
- [A] [Digital Metropolis](#) (Denver, CO), 303-292-4692.

- [A] [Digital Outpost](#) (CA), 800-464-6434.
- [A] [Digital Safari](#) (UK), +44 (0)7092 144 480.
- [A] [Digital Video Compression Corporation \(DVCC\)](#) (CA), 818-777-5185.
- [A] Digital Video Dynamix (Seafood, NY), 516-826-6414.
- [A] Digital Video Mastering (Sydney, Australia).
- [R] [Digital Video Technology 3000](#) (DVT) (El Segundo, CA).
- [A] [Digitonium](#) (Los Angeles, CA), 818-889-2215.
- [A] [Digiverse](#) (London, UK), +44 (0) 20 7287 3141.
- [R] DISC (Orem, UT).
- [R] [Disc Makers](#) (Pennsauken, NJ; Fremont, CA), 800-468-9353.
- [R] Disc Manufacturing Inc. (now part of Cinram).
- [R] [DiscBurn.Com](#) (St. Paul, MN), 612-782-8200.
- [R] [Disctronics](#) (Southwater, UK; Plano, TX; Saint Mande, France; Italy).
- [R] [Disk Press International](#) (Erembodegem, Belgium), +32 53 78 48 14.
- [A] [Directorsite](#) (Manhattan Beach, CA), 310-727-2770.
- [A] [DGP](#) (London, UK), +44 0 207 734 4501.
- [R] [DOCdata](#) (Tilburg, The Netherlands, +31 13 544 6444; Berlin, Germany, +49 30 467 0840; Sanford, ME, USA, 207-324-1124; Canoga Park, CA, USA 818-341-1124).
- [A] [DownStream Digital](#) (Portland, OR), 503-226-1944.
- [A] [DVD Austin](#) (Round Rock, TX), 800-831-3774.
- [A] [DVD Labs](#) (Princeton, NJ), 888-DVD-LABS.
- [A] [DVD Master](#) (Fountain Valley, CA), 714-962-4098.
- [A] [DVD Masters](#) (Calgary, Canada), 403-230-1505.
- [A] [DVD Power](#) (Auckland, New Zealand), +64 (9) 415 5639.
- [A] [DVD Power](#) (Singapore), +65 7796155.
- [A] [DVD Recording Center](#) (Acton, MA), 800-321-8141.
- [A] [DVD Technologies](#) (Sydney, Australia), 1-300-FOR-DVD.
- [A] [DVD Transfer.com](#) (Minneapolis, MN), 612-676-1165.
- [A] [DVD Scandinavia](#) (Copenhagen, Denmark), +45 3581-7585.
- [A] [DVDworx](#) (Philadelphia, PA), 215-238-9679.
- [A] [DVData](#) (Carson, CA) 310-513-0757.
- [A] [Dynamic Media](#) (Ellicott City, MD), 410-203-2553.
- [R] [DV Line](#) (Seoul, Korea), 82-2-3462-0331.
- [A] [DVM - Digital Video Mastering](#) (Sydney, Australia), +61 2 9571 6767.
- [A] [EagleVision](#) (Stamford, CT), 800-EAGLE73.
- [R] [Ecofina](#) (Milan, Italy), +39 024816121.

- [A] EDS Digital Studios (CA), 213-850-1165.
- [A] [Electric Switch](#) (London), +44-0-131-555-6055.
- [R] [EMI Operations Italy](#) (Caronno Pertusella (VA), Italy), +39 02 965111.
- [A] [E-M-S](#) (Dortmund, Germany), 0231 442411-0.
- [A] [Ent/Gates Productions](#) (Buffalo, NY), 716-692-0064.
- [A] [escape lab](#) (Brussels, Belgium) +32 2 644 99 62.
- [R] [Euro Digital Disc](#) (Görlitz, Germany), +49 (0) 35 81 - 85 32 0.
- [A] [FatDisc](#) (Seattle, WA), 206-547-3055.
- [A] Film- und Videotechnik B. Gurtler (Munche, Germany).
- [A] Firefly (Ireland).
- [A] [Fitz.com](#) (Santa Monica, CA) 310-315-9160.
- [A] [Flare DVD](#) (London, UK), +44 (0) 20 7343 6565
- [A] [Forest Post Productions](#) (Farmington Hills, MI), 248-855-4333.
- [A] [Full Circle Studios](#) (Buffalo, NY), 716-875-7740.
- [A] [FULLSTREAM DVD](#) (Dallas, TX), 214-969-1820.
- [R] [Future Media Productions](#) (Valencia, CA), 661-294-5575.
- [A] [Future Disc Systems](#) (West Hollywood, CA), 323-876-8733.
- [A] G9 Interactive (Monrovia, CA), 626-358-0859.
- [A] [Gateway Mastering Studios](#) (Portland, ME), 207-828-9400.
- [R] Gema OD (Madrid, Spain), +34 91 643 42 55,
- [A] [Gnome Digital Media](#) (Burbank, CA), 818-563-6539.
- [R] [GoldenROM](#) (Canonsburg, PA), 888-757-3472.
- [A] [GTN](#) (Oak Park, MI), 248-548-2500.
- [A] [GVI](#) (Washington, DC), 202-293-4488.
- [A] [HAVE](#) (Hudson, NY), 518-828-2000.
- [A] [hdmg](#) (Minneapolis, MN), 952-943-1711.
- [A] [HD Studios](#) [DVD-Audio only] (CEDEX, Suresnes, France).
- [A] Hecker & Schneider GmbH (Dortmund, Germany).
- [A] [Henninger Interactive Media](#) (Arlington, VA), 703-243-3444.
- [A] [HNC Video/DVD Production](#) (Chicago, IL), 847-338-6560.
- [A] [Hoboken Entertainment](#) (Los Angeles, CA), 310-470-9440.
- [A] [Hoek & Sonépouse](#) (Diemen, The Netherlands), +31 020 - 69 09 141.
- [R] [Home Run Software Services](#) (Huntington Beach, CA), 714-375-5454.
- [A] [Ibis Multimedia](#) (Suffolk, UK), +44 01473 288865.
- [A] [IBM InteractiveMedia](#) (GA), 770-835-7193.

- [A] [IBT Media](#) (Merriam, KS), 913-677-6655.
- [R] Imation (formerly 3M) (WI), 612-704-4898.
- [A] [Immediate Impact](#) (UK), +44 01322 553 505.
- [R] [Infodisc](#) (Taipei, Taiwan, 886-2-22266616; El Paso, TX).
- [A] [Instinct Video & Film Productions](#) (Orlando, FL), 407-647-9555.
- [A] [International Digital Centre \(IDC\)](#) (New York, NY), 212-581-3940.
- [A] [IPA Intermedia](#) (IL), 773-871-6033.
- [R] [IPC Communication Services](#) (Foothill Ranch, CA), 949-588-7765.
- [A] [JamSync](#) (Nashville, TN), 615-320-5050.
- [A] [Javanni Digital Video](#) (Atlanta, GA), 704-795-7712.
- [R] [JVC Disc America](#) (Sacramento, CA), 310-274-2221.
- [R] [KAO Infosystems](#) (Fremont, CA), 800-525-6575.
- [R] Kao (Ontario, Canada), 800-871-MPEG.
- [A] [kdg mediatech](#) (Elbigenalp, Austria, +43 (0) 5634-500; Parc d'Activités, France, +33 (0) 3 29 58 40 70).
- [A] [k-kontor\[Hamburg\] kommunikations](#) (Hamburg, Germany), +49-40-850-9021.
- [A] [The Lawrence Company](#) (Santa Monica, CA), 310-452-9657.
- [R] [LaserPacific](#) (CA), 213-462-6266.
- [R] [Lena Optical Disc](#) (Hong Kong), 852-2556-8198
- [A] [Look and Feel New Media](#) (Kansas City, MO), 816-472-7878.
- [A] [The Machine Room](#) (London, UK), +44 171 734 3433.
- [A] [Mares Multimedia](#) (Nashville, TN), 615-356-3905.
- [A] [Marin Digital](#) (Sausalito, CA), 415-331-4423.
- [A] [Main Point Interactive](#) (Oley, PA), 610-987-9320.
- [R] [Marcorp](#) (Pittsburgh, PA), 800-284-6277.
- [A] [Mastering Studio München](#) (Munich, Germany), +49-89-286692-0.
- [R] Maxell Multimedia (now MD Digital).
- [R] Maxwell Productions (Scottsdale, AZ).
- [R] MD Digital Manufacturing (Madison, GA), 706-342-3425.
- [R] [Media Group](#) (Fremont, CA), 815-356-9484.
- [A] [Media Tech](#) (Denver, CO), 303-741-6878.
- [A] [Meedja](#) (London, UK), +44 (0)20 8747 2055.
- [R] [Megalodon](#) (Ashland, OR), 888-234-2283.
- [R] Memory-Tech Corporation (Tokyo, Japan).
- [A] [MEP Medienhaus](#) (Frankfurt, Germany), +49 (0)69 78960202.
- [R] [Mercury Entertainment](#) (Selangor Darul Ehsan, Malaysia).

- [R] [Metatec](#) (Dublin, OH, 614-761-2000; Milpitas, CA, 408-519-5000; [Breda](#), Netherlands, +31 76 5333 100)
- [A] [Metcom Video](#) (London, UK), +44 (0)207 836 2772.
- [A] [Metropolis Group](#) (London, UK), +44-20-8742-1111.
- [A] [Microsoft Studios Digital Video Services](#) (Redmond, WA).
- [A] [Microvision Services](#) (Huddersfield, UK), +44 1484 644852.
- [R] [Midwest Replication](#) (Milwaukee, WI), 414-963-4469.
- [A] [Mills/James Productions](#) (Columbus, OH), 614-777-9933.
- [A] [Mirage Video Productions](#) (Boulder, CO), 303-786-7800.
- [A] [MPEG Production](#) (Stockholm, Sweden), +46-8-324030.
- [A] [MPL Media](#) (Nashville, TN), 800-844-1675.
- [R] [MPO](#) (Europe, North America, and Asia), +33 01 41 10 51 51.
- [R] [MRT Technology](#) [Ritek partner] (City of Industry, CA), 626-839-5555.
- [R] [Multimedia Info-Tech](#) [Ritek partner] (Belfast, Ireland), +44 (0) 2890 300883.
- [R] [Multi Media Replication](#) (Andover, UK) +44 (0)1264 336 330.
- [R] [Nimbus CD International](#) (see Technicolor).
- [A] [NOB Interactive](#) (Netherlands), +31 (0)35-677-5413.
- [A] [NordArt Video & Multimedia](#) (Sundbyberg, Sweden), +46 8764 66 90.
- [R] [Nordisc](#) (Rjukan, Norway), +47 35 08 01 00.
- [A] [Oasis Post](#) (Kent Town, South Australia), +61 8 8362 2888.
- [A] [Oasis Television](#) (London, UK), +44 (0) 20 7534 1808.
- [R] [OEM](#) (Charlotte, NC), 704-504-1877.
- [R] [Optical Disc Corporation](#), 562-946-3050. (LaserWave DirectCut DVD recorder for creating single copies.)
- [R] Optical Disc Media (CA).
- [R] [Optimes](#) (L'aquila, Italy), +39-0862-3311.
- [A] [Option Facilities](#) (Mechelen, Belgium), +32/15/28 73 00.
- [A] [The Other Side](#) [nee TwoPlusOne] (London, UK), +44 (0) 207 494 8290.
- [A] [OUTPOST](#) (Charlotte, NC), 704-344-3577.
- [A] Pacific Coast Sound Works (CA), 213-655-4771.
- [R] Pacific Mirror Image (Melbourne, Australia).
- [A] Pacific Ocean Post (CA), 310-458-9192. (Now part of Liberty Livewire)
- [A] [Pacific Video Resources](#) (CA), 415-864-5679.
- [R] [Panasonic Disc Services Corp](#) (Torrance, CA; Pinckneyville, IL; Guadalajara, Mexico; Youghal, Ireland), 310-783-4800.
- [A] Paris Media System (Paris, France).

- [A] [Paul Stubblebine Mastering and DVD](#) (San Francisco, CA), 415-469-0123
- [A] [The Pavement](#) (London, UK), +44 (0) 207 426 5190.
- [A] [Performance Digital Labs](#) (San Diego, CA), 800-253-3085.
- [A] [Phaebus](#) (Manchester, UK), +44 (0) 161 950 8105.
- [A] [PIMC \(Professional Interactive Media Centre\)](#) (Diepenbeek, Belgium), +32 11 303690.
- [A] Pioneer France (Nanterre, France), 33 1 47 60 79 30.
- [R] [Pioneer Optical Disc](#) (Barcelona, Spain), +34-93-739-99-00.
- [R] [Pioneer Video](#) (Kofu, Japan).
- [A] [Pixel Farm Interactive](#) (Minneapolis, MN), 612-339-7644.
- [A] [Positive Charge Ltd.](#) (Warszawa, Poland), +48 22 632 97 32.
- [R] [Pozzoli](#) (Milan Italy) +39 02 954341.
- [A] [PRC Digital Media](#) (Jacksonville, FL), 904-354-5353.
- [A] [Prime Disc](#) [Ritek partner] (Wiesbaden, Germany), +49-611-9628644.
- [A] [Provac Disc Media](#) (Toronto, Ontario), 800-876-9013.
- [R] [Racman Avdio Video Studio](#) (Ljubljana, Slovenia), +386 1 5819 201.
- [A] [Rage DVD & Multimedia](#) (Dallas , TX), 214-358-2588.
- [A] [Rainmaker New Media](#) (Burbank, CA), 818-526-1500.
- [A] [Riccelli Creative](#) (Fort Worth, TX), 817-332-7777.
- [A] [The Richard Diercks Company](#) (Minneapolis, MN), 612-334-5900.
- [A] [RISE Int'l. Inc.](#) (Fort Worth, TX), 800-990-2348.
- [R] [Ritek](#) (HsinChu, Taiwan, ROC, +886-3-598 5696; Taipei, Taiwan, ROC, +886-2-8521-5555).
[Also see MRT U.S.), Multimedia Info-Tech (Ireland), Prime Disc (Germany), and Ritek Australia.]
- [R] [Ritek Australia](#) (Alexandria, Australia), +61-2-9669-3311).
- [A] [Rivetal](#) (Provo, UT), 801.818.2222.
- [A] [RTF-FX and Video Services](#) (Nashua, NH), 866-843-3611.
- [A] [Saga Productions](#) (New York, NY), 646-825-9063.
- [R] [Saturn Solutions](#) (Markham, Ontario, 905-470-0844; St. Laurent, Quebec, 514-856-5656; Provo, Utah, 801-370-9090; Dublin, Ireland, +353-1-403-8599).
- [A] [ScreamDVD](#) (New York, NY), 212-951-7171.
- [R] [SDC Group](#) (Brabrand, Denmark), + 45 87 45 45 45.
- [A] [Sharpline Arts](#) (Glendale, CA), 818-500-3958.
- [R] [SKC](#) (Chonan, South Korea).
- [R] [SNA](#) (Tourouvre, France), +33 (0) 2 33 85 15 15.
- [R] [Sonopress](#) (Gütersloh, Germany, +49-5241-80 5200; Weaverville, NC, USA, 828-658-2000; Dublin, Ireland, +353 1 840 9000; Madrid, Spain, +34-91-6 71 22 00; Forbach, France, +33-1-53 43 82 32).
- [R] [Sony DADC](#) (Niederalm, Austria), +43 624 688 0555.

- [R] [Sony Disc Manufacturing](#) (Terre Haute, Indiana), 800-358-7316.
- [A] [Sound Chamber Mastering](#) (North Hollywood, CA), 818-752-7581.
- [A] [SOUNDnVISION](#) (Milano, Italy), +39 02 55 18 02 45.
- [R] [Spinergy](#) (East Rochester, NY), 800-333-1428.
- [R] [Spool Multi Media](#) (Deeside, UK), +44 (0) 1244 280602.
- [A] [Squash DVD](#) (London, UK) +44 (0) 20 7292 0222.
- [A] [Star Video Duplicating](#) (Phoenix, AZ), 602-437-0646.
- [A] [Stay Tuned](#) (Brussels, Belgium), +32 2 7611100.
- [A] Stimulus (Calgary, Alberta).
- [A] [Sté EXILOG](#) (Vendoeuvres FRANCE), 33 02 54 38 30 95.
- [A] [Stonehenge Filmworks](#) (Toronto and Ontario, Canada), 416-867-1189.
- [A] [Stream AV](#) (Melbourne, Australia), +61 3 9376 6444.
- [A] [Studio Reload](#) (Boise, ID), 208-344-4321.
- [A] [Sunset Post](#) (CA), 818-956-7912.
- [A] [Super Digital Media](#) (Santa Clara, CA), 408-727-5091.
- [A] [Supersonic Media Productions](#) (Vancouver, BC), 604-683-0250.
- [A] Sync Sound (NY), 212-246-5580 (5.1 audio).
- [A] [Syrinx music & media GmbH](#) (Hamburg, Germany), +49-40-63709230.
- [A] [Systeam](#) (Rome, Italy), +39-06-508141.
- [A] [Tape House Broadband](#) (New York, NY), 212-557-4949.
- [R] [Takt](#) (Warsaw, Poland), +48 22 874 35 75.
- [A] [TC Video](#) (Middlesex, UK), +44 (0)208 904 6271.
- [R] [Technicolor](#) (Burbank, CA, 818-260-3800; Camarillo, CA, 805-445-1122; Charlottesville, VA, 804-985-1100; Cwmbran, Wales, UK, 44-1163-465-000), 800-732-4555).
- [R] [TIB](#) (Merthyr Tydfil, UK), + 44 (0)1685 354700.
- [A] [Tobin Productions](#) (New York, NY), 212-727-1500.
- [R] [Tocano](#) (Smoerum, Denmark), +45 44666200.
- [D] [Tree Falls](#) (Los Angeles, CA), (323) 851-0299.
- [D] [US DigitalMedia](#) (Phoenix, AZ), 877-992-3766.
- [R] [Universal Manufacturing & Logistics](#) (Blackburn, UK, +44 (0) 1254 505300; Langenhagen, Germany, +49 (0) 511-972-1755).
- [A] [US DVD](#) (San Jose, CA), 408-259-1495.
- [A] [Valkieser Solutions](#) (Hilversum, Netherlands), +31-35-6714-300.
- [A] [VDI Multimedia](#) (Chicago, Dallas, Los Angeles, New York, San Francisco), 323-957-7990.
- [R] [VDC Group](#) (Wembley, UK), +44 (0)208 903 3345.
- [A] [Versatile Media One \(VM1\)](#) (Montreal, PQ), (514) 876-0102.

- [R] Japan Victor (Kanagawa, Japan), 45-453-0305.
- [A] [Video Movie Magic](#) (Laguna Hills, CA), 949-582-8596.
- [A] [Video Replay](#) (Chicago, IL),
- [A] [Video Transfer](#) (Boston, MA), 617-247-0100.
- [A] [Visible Light Digital](#) (Orlando, FL), 407-327-7804.
- [A] [Visom Digital](#) (Rio de Janeiro, Brazil), +55 21 539-7313.
- [A] [The Vision Factory](#) (St. Louis, MO), 314-963-7887.
- [A] [Vision Wise](#) (Irving, TX), 888-979-9473.
- [R] [Warner Advanced Media Operations](#) (WAMO), 717-383-3291.
- [A] [The Zak Studio](#) (Paris, France), +33 1 49823773.
- [R] [Zomax](#), (Plymouth, MN, 612-577-3515; Fremont, CA, 510-492-5191; Indianapolis, IN, 510-492-5191; Dublin, Ireland, 353-1-405-6222; Langen, Germany, 49-6103-9702-23).
- [A] Zuma Digital. Now part of [Tape House Broadband](#).

[5.6] What testing/verification services and tools are available?

- [AudioDev](#) (Sweden, USA, Hong Kong), +46 40 690 49 00.
- [CD Associates](#) (CA). Testing equipment and software. (714) 733-8580.
- [ContentWise](#) (Rehovot, Israel), +972-8-940-8773. *Second Sight* software for checking compatibility of DVD titles on multiple players.
- Hitachi (Japan). Testing services and test discs. Official DVD Forum verification lab.
- [Intellikey Labs](#) (Burbank, CA), (818) 953-9116, fax (818) 953-9144.
- [Interra Digital Video Technologies](#): *Surveyor* software, \$6,000. *DProbe*, \$10,000.
- [ITRI](#) (HsinChu, Taiwan). Testing services and test discs. Official DVD Verification Lab. 886-3-591-5066, fax 886-3-591-7531.
- Matsushita (Japan). Testing services, test discs, and test equipment. Official DVD Verification Lab. +81-6-6905-4195 fax +81-6-6909-5027.
- Matsushita/Panasonic (Japan). *Panasonic LQ-VD300P* emulator. Hardware player with Windows NT software. \$15,000.
- [Philips](#) (Europe), *DVD-Video Verifier* software, \$500. Official DVD Verification Center.
- Pioneer (Japan). Testing services and test discs. Official DVD Verification Lab. +81-3-3495-5474, fax +81-3-3495-4301.
- [PMTC \(Professional Multimedia Test Centre\)](#) (Diepenbeek, Belgium), +32 11 303636.
- [Sonic Solutions](#) (USA). *DVD PrePlay* software. Emulation and diagnosis tools for Windows. \$5000.
- Sony (Japan). Testing services and test discs. Official DVD Format Lab. +81-3-5448-2200, fax +81-3-5448-3061.
- [Testronic Labs](#) (Burbank, CA), (818) 845-3223, fax (818) 845-3236.
- Toshiba (Japan). Testing services and test discs. Official DVD Verification Lab. +81-3-3457-2105, fax +81-3-5444-9202.
- Victor (Japan). Testing services and test discs. Official DVD Verification Lab. +81-3-3289-2813, fax +81-45-450-1639.

- [WAMO](#) (USA). Testing services and test discs. Official DVD Forum verification lab. 1-570-383-3568, fax 1-570-383-7487.

Also see [5.3.3](#) for tools to analyze and verify coded bitstreams, disc images, and DLTs.

[5.7] Can I put DVD-Video content on a CD-R or CD-RW?

[Note: This section refers to creating original DVD-Video content, not copying from DVD to CD. The latter is impractical, since it takes 7 to 14 CDs to hold one side of a DVD. Also, most DVD movies are encrypted so that the files can't be copied without special software.]

There are many advantages to creating a DVD-Video volume using inexpensive recordable CD rather than expensive recordable DVD. The resulting "cDVD" (also called a "miniDVD") is perfect for testing and for short video programs. Unfortunately, you can put DVD-Video files on CD-R or CD-RW media, or even on pressed CD-ROM media, but almost no set-top player can play the disc. There are a number of reasons DVD-Video players can't play DVD-Video content from CD media:

- 1) checking for CD media is a fallback case after DVD focus fails, at which point the players are no longer looking for DVD-Video content
- 2) it's simpler and cheaper for players to spin CDs at 1x speed rather than the 9x speed required for DVD-Video content
- 3) many players can't read CD-R discs (see [2.4.3](#)).

The only known players that can play a cDVD are the Afreey/Sampo LD2060 and ADV2360 models, and the Aiwa XD-DW5 and XD-DW1. Some of these players use 1x or 2x readers so they can't handle data rates over 4 Mbps. It's possible to replace the IDE drive mechanism in the player with a faster drive, which can then handle higher data rates. See [robshot.com](#) for details on cDVD-capable players. (Note: there have been many reports of players able to play DVD content from CD-R. Upon investigation it turns out that they play Video CDs but not cDVDs. The players mentioned above have been verified to play DVD-Video files (.VOB and .IFO) from CD media.)

Computers are more forgiving. DVD-Video files from any source with fast enough data rates, including CD-R or CD-RW, with or without UDF formatting, will play back on most DVD-ROM PCs as long as the drive can read the media (all but early model DVD-ROM drives can read CD-Rs). On a Mac, you need version 2.3 or newer of the [Apple DVD Player](#).

To create a cDVD, author the DVD-Video content as usual (see [5.4](#)) then burn it to a CD-R or CD-RW. If your authoring software doesn't write directly to CD-R/RW discs, use a separate utility to copy the VIDEO_TS directory to the root directory of the disc. To be compatible with the few settop players that read cDVDs, turn on the UDF filesystem option of the CD burning software. To achieve longer playing times, encode the video in MPEG-2 half-D1 format (352x480 or 352x576) or in MPEG-1 format.

An alternative is to put Video CD or Super Video CD content on CD-R or CD-RW media for playback in a DVD player. Set-top DVD players that are VCD or SVCD capable and can read recordable media will be able to play such discs (see [2.4.5](#)). The limitations of VCD apply (MPEG-1 video and audio, 1.152 Mbps, 74 minutes of playing time). All DVD-ROM PCs able to read recordable CD media can play recorded VCD discs. An MPEG-2 decoder (see [4.1](#)) is needed to play SVCDs. See [5.8](#) for more on creating Video CDs.

[5.8] How do I copy my home video/film/photos to DVD?

This used to be almost impossible, but luckily for you it's getting cheaper and easier all the time.

For a simple video-to-DVD transfer you can buy a DVD video recorder (\$500 to \$3,000) and connect it to your VCR or camcorder. It works just like a VCR but it records onto a disc instead of tape.

For transferring photos or music, or for making a customized DVD with menus and chapters and other fun stuff, you'll need the following:

- A computer
- A DVD recordable drive (\$100-\$400, or it might come with the computer)
- DVD authoring software (usually comes with the drive or computer, or you can buy it for \$40-\$27,000, see [5.4](#)).

Note: You must use authoring software. You can't just copy MPEG or AVI or JPEG files onto a disc and expect it to play in DVD players.

Then take the following steps

- If the video and pictures are not already in digital form (AVI, WMV, DivX, QuickTime, JPEG, and so on) you need to transfer them to your computer. For analog video, such as VHS and Hi8, you need a video capture device or a computer with built-in analog video input; for digital video such as DV or D8 you need a 1394/FireWire input on the computer. For film, first have it transferred to tape or digital video at a camera shop or video company (see a [list](#) at HomeMovieDay.com). For slides or photos, use a scanner (or rent scanning time at a place such as Kinkos).
- Import the video and audio clips into the DVD-Video authoring program. Many DVD authoring programs will convert and encode the video and audio for you. If not, you have to
 - Encode the video into MPEG-2 (make sure the display frame rate is set to 29.97 for NTSC or 25 for PAL).
 - Encode the audio into Dolby Digital (or, if your video is short enough that you have room on the disc, format the audio as 48kHz PCM). You can also use MPEG Level 2 audio, but it won't work on all players.
- Create some chapter points in your video tracks or let the DVD recording software do it for you.
- To put photos on the disc, use the slideshow feature in the authoring software or make each picture a menu. Most DVD authoring software will directly read TIFF, JPEG, BMP, and PhotoShop files.
- Create menus that link to your video clips and slideshows.
- Write your finished gem out to a recordable DVD (\$2-\$15). (But see [4.3.1](#) for compatibility worries.)

John Beale has written a [page](#) about his experiences making DVDs.

Another option is to use a service that does all the work for you at a reasonable fee. Here are a few choices.

- [3-Lib](#) (Reading, UK). Up to 2 hours for £25. PAL format.
- [American Digital Media](#) (Hoover, AL). Up to 2 hours for \$99.
- [Digital Video Dynamics](#) (Orlando, FL). Up to 2 hours for \$40 (chapters at 5-minute intervals).
- [DV4U Online.com](#) (Sacramento, CA). Up to 2 hours for \$150.
- [DVD ELF](#) (Miami, FL). Up to 1 hour for \$60. 2 hours for \$95.
- [DVD Wedding Productions](#) (South Pasadena, CA). One tape for \$150 (+ VHS dubbing charge).
- [HomeMovie.com](#) (Everett, WA). Up to 2 hours for \$50 (chapters included).
- [ImageStation](#) (Sony/[Vingage](#); Reston, VA). Up to 90 minutes for \$40.
- [Latale Productions](#) (Flushing, NY). 1 tape for \$99 (chapters extra).
- LifeClips (Acton, MA). Up to 2 hours for \$30. *[LifeClips is no longer in business.]*
- [Memories on Disc](#) (Princess Anne, MD). \$0.50 per minute of video, \$1.00 per slide.
- [save2dvd](#) (Pleasant Hill, CA). Up to 2 hours for \$140. Also film and slide transfer.
- [ScreamDVD](#) (New York, NY). Up to 1 hour for \$40, up to 2 hours for \$70 (chapters at 3-minute intervals).
- [VHS-to-DVD](#) (Pembroke Pines, FL). Up to 1 hour for \$18-\$25, up to 2 hours for \$28-\$35.
- [Visualisation Systems](#) (Preston, UK). Up to 1 hour for £35. Up to 2 hours for £40. VCD for £20.
- ([Wedding DVD](#) no longer offers the service.)

- YesVideo.com (San Jose, CA; kiosks at Target, Walgreens, and elsewhere). \$37 for 1 hour, \$60 for 2 hours (chapters included).

Or, if near-VHS quality is sufficient, make a Video CD. Get MPEG-1 video encoding software and a CD-R/RW formatting application that supports Video CD such as *Easy CD Creator* or *Toast* from Roxio (formerly Adaptec), *InstantCD* from Pinnacle (formerly from VOB), *InternetDiscWriter* from Query, *MPEG Maker-2* from VITEC, *MyDVD* or *RecordNow Max* from Sonic, *Nero Burning ROM* from Ahead, *NTI CD-Maker* from NTI, or *WinOnCD* from Cequadrat. Quality is not as good as DVD, and playing time is not as long, but hardware and blank CDs are cheaper. Just make sure that any players you intend to play the disc in can read CD-Rs (see [2.4.3](#)) and can play Video CDs (see [2.4.5](#)). See VCDhelp.com for more on making Video CDs. A variation on this strategy is to make Super Video CDs (see [2.4.6](#)), which have better quality but shorter playing time. A few of the authoring/formatting tools listed above can make SVCDs, but few DVD players can play SVCDs.

Another option is a home Video CD recorder, such as the [Terapin CD Audio/Video Recorder](#) or the [TV One MPEG-2@disk](#), which record video from analog inputs to CD-R or CD-RW.

[5.9] How can I copy a DVD?

This section is about copying disc-to-disc. See [2.11](#) for copying to tape. See [4.13](#) for copying audio.

First, please understand that copying a commercial DVD may be illegal, depending on what you do with the copy. Copying video for your own personal use may be legal, but making copies of copyrighted discs for friends is not.

Second, be aware that almost all DVD movies are protected from casual copying. See [1.11](#) for details. However, any protection measure is usually broken, see [4.8](#).

Third, realize that many movies come on dual-layer discs (DVD-9s), which can't be directly copied to recordable DVD since dual-layer recordable discs aren't out yet. Though you may be able to break up the content from one DVD-9 onto two recordable discs. Some of the copying software below can recompress the video to fit on a single-layer recordable DVD, but the picture quality will suffer.

Fourth, understand that simply copying the computer files from a DVD to a recordable DVD often produces a disc that won't play in a set-top DVD player, since the files have to go in specific order and specific places on the disc. Some DVD writing software recognizes the files and places them correctly, but other software doesn't. In other words, you can't just copy the .IFO and .VOB files (see [4.10](#)).

If you have a legitimate need to copy a DVD, such as a disc you made yourself, there are a number of options. You can hook a DVD player to a set-top DVD video recorder. Some DVD authoring software (see [5.4](#)) can import video from an unprotected disc. There are computer software utilities you can use to extract video and audio from a disc, which you can then use to make a new disc. There are also software tools for copying entire discs, see the list below and also see [6.4.2](#) and [5.3.3](#). See [5.8](#) for how to make your own DVDs.

Beware of e-mail and ads touting DVD copying software for sale. See [5.9.1](#) below.

DVD copying software:

- *Clone DVD** from [DVD X Studios](#)
- *CloneDVD** from [Elby](#)
- [Copy DVD Pro*](#)
- *DVD Copy* from [Intervideo](#)
- [DVD Wizard Pro*](#)
- *DVD X Copy** from [321 Studios](#)
- [DVD2one*](#)
- [DVD-Cloner*](#)
- *RecordNow* from [Sonic](#)

* Can copy CSS-protected movies (which is illegal because of the DMCA, see [1.11](#))

[5.9.1] What's with those "Copy any DVD" e-mails?

It's true you can copy any DVD movie. However the people selling DVD copying software conveniently don't mention the many free alternatives, nor do most of them mention that their applications only copy to CD-R/RW in Video CD format, which means the video quality is crummy and the copies don't play in about half the DVD players out there (see [2.4.3](#) and [2.4.5](#)). They also neglect to mention that copying movies from rental stores or from friends is illegal.

[5.10] How do I get a job making DVDs?

Read this FAQ through a few times. For extra credit read my book, [DVD Demystified](#), and visit some of the DVD information sources listed in section [6.4](#). Then attend a conference (see [5.10](#)) to learn more and to make contacts in the DVD industry. Take a few training courses (see [5.10](#)). Consider joining the [DVDA](#). If you can, volunteer to be an intern at a DVD production house (see [5.5](#)).

Once you have a little experience, you'll be in great demand!

[5.11] Where can I get DVD training?

A variety of workshops and seminars on various DVD topics are presented at conferences such as [DVD Pro](#), [DVD Summit](#) (Europe) or [DVD Production](#).

Training companies offer DVD courses and "boot camps":

- [adicom](#) (Costa Mesa, CA)
- [dvd.learn](#) (Denver, CO)
- [Ex'pression Center for New Media](#) (Emeryville, CA)
- [Gnome Digital Media](#) (Burbank, CA), maker of the *DVD 101* training/template discs
- [I.N.C. Technologies](#) (Glendale, CA), oriented towards amateur DVD users
- [TFDVD.com](#) (Havertown, PA), *DVD Studio Pro* training
- [Seneschal](#) (San Francisco, CA)
- [Texas State Technical College](#) (Waco, TX)
- [Video Symphony](#) (Burbank, CA)

There are a few schools with full-term courses:

- [College of San Mateo](#) (California), DVD Studio Pro class
- Ngee Ann Polytechnic [Digital Media Authoring Studio](#) (Singapore)
- [Seneca College](#) (Toronto, CA)
- [South Seas Film and Television School](#) (Auckland, New Zealand)

The major DVD authoring software companies offer training classes around the world, sometimes for free:

- [Apple Computer](#)
- [Sonic Solutions](#)

[5.12] How can I sell DVDs that I made?

- [Amazon zShops](#). Sales referrals. Your disc is listed on Amazon site, Amazon processes orders, you are responsible for producing, packaging, and shipping discs.

- [CustomFlix](#). Duplication and e-commerce consignment. You give them a disc (or tape that they turn into a disc), they handle order processing, copying onto DVD-Rs, labeling, packaging, and shipment. No minimum.
- Auction sites such as [eBay](#), [Amazon Auctions](#), [Yahoo Auctions](#), [uBid](#), and [many others](#). Site runs auction, you are responsible for taking payment, producing, packaging, and shipping discs.

If you are looking for someone to deliver your titles to retailers, see [6.2.2](#) for distributors.

[5.13] How do I put a PowerPoint presentation on DVD?

There's not yet a feature in PowerPoint to export directly to video on DVD, but you can convert a PowerPoint presentation to stills or video for import into a DVD authoring program (see [5.8](#)). Recent versions of PowerPoint allow you to save your slides as graphic images (JPEG or PNG files) that can be imported into a DVD authoring program that supports slideshows. The advantage of using the slideshow feature is that you can have the DVD player pause indefinitely on each still until you press the Enter or Play key on the remote control. (Note: make sure the authoring software supports true slideshows with "infinite stills," since many programs just render slides as video.) The disadvantage of using stills is that you won't get animations and other fancy PowerPoint effects. Alternatively you can record the PowerPoint presentation as a video file (use a PowerPoint add-in or a motion screen capture program) and import the video file into the DVD authoring program. This preserves the full visual effect but locks you into the timing you used when recording the presentation. Another alternative is [321 Studio's DVD X Point](#), which directly converts PowerPoint presentations (version 2002 only) to DVD slideshows.

[6] Miscellaneous

[6.1] Who invented DVD and who owns it? Whom to contact for specifications and licensing?

DVD is the work of many companies and many people. DVD evolved from CD and related technologies. Some of the early proposals for "high-density CD" were made in 1993, and these efforts gradually coalesced into two competing proposed formats. The MMCD format was backed by Sony, Philips, and others. The SD format was backed by Toshiba, Matsushita, Time Warner, and others. A group of computer companies led by IBM insisted that the factions agree on a single standard. The combined DVD format was announced in September of 1995, avoiding a confusing and costly repeat of the VHS vs. Betamax videotape battle or the quadraphonic sound battle of the 1970s.

No single company "owns" DVD. The official specification was developed by a consortium of ten companies: Hitachi, JVC, Matsushita, Mitsubishi, Philips, Pioneer, Sony, Thomson, Time Warner, and Toshiba. Representatives from many other companies also contributed in various working groups. In May 1997, the DVD Consortium was replaced by the [DVD Forum](#), which is open to all companies, and as of February 2000 had over 220 members. Time Warner originally [trademarked](#) the DVD logo, and has since assigned it to the DVD Format/Logo Licensing Corporation (DVD FLLC). The written term "DVD" is too common to be trademarked or owned. See section [6.2](#) and visit Robert's [DVD Info page](#) for links to Web sites of companies working with DVD.

The official DVD specification books are available after signing a nondisclosure agreement and paying a \$5,000 fee. One book is included in the initial fee; additional books are \$500 each. Manufacture of DVD products and use of the DVD logo requires additional format and logo licenses, for a one-time fee of \$10,000 per format, minus \$5,000 if you have already paid for the specification. (E.g., a DVD-Video player manufacturer must license DVD-ROM and DVD-Video for \$20,000, or \$15,000 if they have the spec.) Allowances are made for production houses and content providers to use the logo in conjunction with a licensed replicator, and for non-licensees to use the DVD logo in publications or presentations (with an option to [request logo art](#)). For more spec and logo information contact [DVD Format/Logo Licensing Corporation](#) (DVD FLLC), Shiba Shimizu Building 5F, Shiba-daimon 2-3-11, Minato-ku, Tokyo 105-0012, tel: +81-3-5777-2881, fax: +81-3-5777-2882. Before April 14, 2000, logo/format licensing was administered by Toshiba.

[ECMA](#) has developed international standards for DVD-ROM (part 1, the smallest part of the DVD spec), available for free download as [ECMA-267](#) and [ECMA-268](#) from [www.ecma-international.org](#). ECMA has also standardized DVD-R in [ECMA-279](#), DVD-RAM in [ECMA-272](#) and [ECMA-273](#), and DVD+RW as [ECMA-274](#) (see [4.3](#)). Unfortunately, ECMA has the annoying habit of spelling "disc" wrong. Also confusing, if you're not from Europe, is ECMA's use of a comma instead of a period for the decimal point.

The specification for the UDF file system used by DVD is available from www.osta.org.

Many technical details of the DVD-Video format are available at the [DVD-Video Information](#) page.

Any company making DVD products must license essential technology patents from the "[3C](#)" pool (LG, Philips, Pioneer, Sony: 3.5% per player/drive, minimum \$3.50; additional \$0.75 for Video CD compatibility; 3.75 cents per disc), the "[6C](#)" pool (Hitachi, IBM, Matsushita, Mitsubishi, Time Warner, Toshiba, Victor: 4% per player/drive, minimum \$4; 4% per "DVD Video decoder", minimum \$1; 5 cents per disc) and from Thomson (~\$1 per player/drive). Patent royalties of 20 cents per disc are also owed to [Discovision Associates](#), which owns about 1300 optical disc patents. Per disc costs are paid by the replicator.

The licensor of CSS encryption technology is [DVD CCA](#) (Copy Control Association), a non-profit trade association with offices at 225 B Cochrane Circle, Morgan Hill, CA. There is a \$20,000 annual licensing fee, but no per-product royalties. Send license requests to css-license@lmicp.com, technical info requests to css-info@lmicp.com. Before December 15, 1999, CSS licensing was administered on an interim basis by Matsushita.

[Macrovision](#) licenses its analog anti-recording technology to hardware makers. There is a \$30,000 initial charge, with a \$15,000 yearly renewal fee. The fees support certification of players to ensure widest compatibility with televisions. There are no royalty charges for player manufacturers. Macrovision charges a royalty to content publishers (approximately 4 to 10 cents per disc, compared to 2 to 5 cents for a VHS tape).

[Dolby](#) licenses 2-channel Dolby Digital decoders or encoders for \$0.66. The fee for a system with both a 2-channel decoder and 2-channel encoder is \$0.71. Multichannel decoders are approximately \$1.50. Philips, on behalf of CCETT and IRT, also charges \$0.20 per channel (maximum of \$0.60 per player) for Dolby Digital patents, along with \$0.003 per disc.

[DTS](#) licenses optional DTS decoders.

[Dolby](#) licenses MLP decoders for DVD-Audio players.

An MPEG-2 patent license is required from [MPEG LA](#) (MPEG Licensing Administrator). Cost is \$2.50 for a DVD player or decoder card and 4 cents for each DVD disc, although there seems to be disagreement on whether content producers owe royalties for discs.

Many DVD players are also Video CD (VCD) players. [Philips](#) licenses the Video CD format and patents on behalf of themselves, Sony, JVC, Matsushita, CNETT, and IRT for \$25,000 initial payment plus royalties of 2.5% per player or \$2.50 minimum.

[Nissim](#) claims 25 cents per player and 78/100ths of a cent for parental management and other DVD-related patents.

Various essential licensing fees add up to over \$14 in royalties, and about \$0.20 per disc. Disc royalties are paid by the replicator.

Royalties for DVD+R patents are charged by Philips (approximately \$0.06 per disc) and Sony (1.5 to 3.5% of disc price).

[6.2] Who is making or supporting DVD products?

[6.2.1] Consumer electronics

- [Afreedy](#): DVD-Video players
- [Aiwa](#): DVD-Audio and DVD-Video players
- [Akai](#): DVD-Video players
- Alba: DVD-Video players
- [Alpine](#): DVD car navigation/entertainment
- [Altec Lansing](#): DVD audio technology
- Amitech: DVD-Video players

- [Amoisonic](#): DVD-Video players
- [Apex Digital](#): DVD-Video players (made by [VDDV](#); info at <www.nerd-out.com/apex>)
- [Arcam](#): DVD-Video players (UK)
- Ariston: DVD-Video players
- Atlantis Land: DVD-Video players
- A-trend: DVD-Video players
- Atta: DVD-Video players
- Audiologic: DVD-Video players
- Audiosonic: DVD-Video players
- [Audiovox](#): Car DVD players
- Axion: DVD-Video players
- AV Phile (Raite): DVD-Video Players
- Bluesky: DVD-Video players
- BUSH: DVD-Video players
- [California Audio Labs](#): DVD-Video players
- CAT: DVD-Video players
- [Camelot](#): DVD-Video players
- [Casio](#): DVD-Video players
- CCE: DVD-Video players
- [CD Playright](#): protective film for discs
- Centrum: DVD-Video players
- Chunlan: DVD-Video players
- Clairtone: DVD-Video players
- [Clarion](#): DVD car navigation/entertainment
- [Comjet](#): DVD-Video players with Web connection
- [Compro](#): DVD-Video players
- Conia: DVD-Video players (Australia, made by [VDDV](#))
- Cougar: DVD-Video players
- [Cyberhome](#) (Yamakawa/Raite): DVD-Video players
- [Daewoo Electronics](#): DVD-Video players
- Dantax: DVD-Video players
- [Denon](#): DVD-Audio and DVD-Video players
- Denver: DVD-Video players
- Digiton: DVD-Video players
- Digitron: DVD-Video players

- [DiViDo](#): DVD-Video players (Netherlands)
- Dual: DVD-Video players
- [DVDO](#): video deinterlacing processors
- Dynamic: DVD-Video players
- [Eagle Wireless International](#): DVD Internet appliances
- Eclipse: DVD-Video players
- Electrohome: DVD-Video players
- Elta: DVD-Video players
- Eltax: DVD-Video players
- [Emerson](#) (Funai): DVD-Video players
- Encore: DVD-Video players
- [Enzer](#): DVD-Video players
- [Esonic](#): DVD-Video players
- [ESS Technology](#): DVD-Video players and WebDVD players
- [Euro Asia Technologies](#): DVD-Video players (UK)
- [Faroudja](#): DVD-Video players
- Finlux: DVD-Video players
- [Fisher](#) (Sanyo): DVD-Video players
- [Funai](#) (Emerson/Orion/Sylvania/Symphonic): DVD-Video players
- [GE](#) (Thomson): DVD-Video players
- Genica: DVD-Video players
- Goodmans: DVD-Video players
- GPX/Yorx: DVD-Video players
- Gradiente: DVD-Video players
- Grandin: DVD-Video players
- [Great Wall](#): DVD-Video players (Hong Kong)
- [Grundig](#): DVD-Video players
- [Guangdong Jinzheng Digital](#): DVD-Video players
- Gynco: DVD-Video players
- Haier: DVD-Video players
- [Harman Kardon](#): DVD-Video players
- [Himage](#): DVD-Video players
- [Hitachi](#): DVD-Video players and recorders
- Hiteker: DVD-Video players (made by VDDV)
- Homemighty: DVD-Video players

- Hoyo (Raite): DVD-Video Players
- [Hyundai](#): DVD-Video players
- [iDVDBox](#): Enhanced DVD-Video Players
- [I-Jam](#): DVD-Video players
- [Innovacom](#): PC/TV with DVD support
- Irradio: DVD-Video players
- Jasmine: DVD-Video players
- Jeutech: DVD-Video players
- JNL: DVD-Video players
- Jocel: DVD-Video players
- [JVC](#) (Victor): DVD-Video players and recorders
- Kendo: DVD-Video players
- Kennex: DVD-Video players
- [Kenwood](#): DVD-Video players
- Keymat: DVD-Video players
- [KiSS](#) (Raite): DVD-Video players
- Kioto: DVD-Video players
- [KLH](#): DVD-Video players
- Kones: DVD-Video players
- [Konka](#): DVD-Video players
- [Labway](#): DVD-Video players
- [Lafayette](#): DVD-Video and DVD-Audio players
- [Lasonic](#) ([Yung Fu](#)): DVD-Video players
- Lawson: DVD-Video players
- Lecson: DVD-Video players
- Lector: DVD-Video players
- Legend: DVD-Video players
- Lenco: DVD-Video players
- Lenoxx: DVD-Video players
- [LG Electronics](#) (GoldStar): DVD-Video players
- Lifetec: DVD-Video players
- Limit: DVD-Video players
- Loewe: DVD-Video players
- Logix: DVD-Video players
- Lumatron: DVD-Video players

- Luxman: DVD-Video players
- [Madrigal](#) (Mark Levinson): DVD-Audio and DVD-Video players
- Magnavox (Philips): DVD-Video players
- Magnex: DVD-Video players
- Majestic: DVD-Video players
- Malata: DVD-Video players
- [Manhattan](#): DVD-Video players
- [Marantz](#) (Philips): DVD-Audio, SACD, and DVD-Video players
- Mark: DVD-Video players
- [Matsushita](#) (Panasonic/National/Technics/Quasar): DVD-Video players and recorders, DVD-Audio players, DVD car navigation/entertainment
- Matsui: DVD-Video players
- [Medion](#): DVD-Video players
- Memorex: DVD-Video players
- [Meridian](#): DVD-Video players
- Metz: DVD-Video players
- MiCO: DVD-Video players
- [Microboss](#): DVD-Video players
- Micromega: DVD-Video players
- Minato: DVD-Video players
- Mintek: DVD-Video players
- Mishine: DVD-Video players
- [Mitsubishi](#): DVD-Video players
- Mitsui: DVD-Video players
- Monica/Monyka (Raite): DVD-Video players
- Mossimo: DVD-Video players (China)
- Mustek: DVD-Video players
- NAD: DVD-Video players
- [Nakamichi](#): DVD-Audio and DVD-Video players
- Napa: DVD-Video players
- [NEC](#): DVD-RAM video camera
- Neufunk: DVD-Video players
- [Nintaus](#) (Guangdong Jinzheng): DVD-Video players
- Noriko: DVD-Video players
- Odyssey: DVD-Video players
- [Olidata](#): DVD-Video players (Italy)

- Omni: DVD-Video players
- [Onkyo](#): DVD-Video and DVD-Audio players
- [Optics-Storage](#): DVD-RW video recorders (supplier)
- Optim: DVD-Video players
- Orava: DVD-Video players
- Orion: DVD-Video players
- [Oritron](#): DVD-Video players
- Palsonic (Australia): DVD-Video players
- [Panasonic](#) (Matsushita): DVD-Video players and recorders, DVD-Audio players
- Philco: DVD-Video players
- [Philips](#) (Magnavox/Marantz/Norelco): DVD-Video players and recorders
- Phoenix: DVD-Video players
- Phonotrend: DVD-Video players
- [Pioneer](#): DVD-Video players and recorders, DVD-Audio players, DVD car navigation/entertainment
- Primare: DVD-Video players
- Proceed: DVD-Video players
- Proline: DVD-Video players
- [Proscan](#) (Thomson): DVD-Video players
- Proson: DVD-Video players
- Proton: DVD-Video players
- Quadro: DVD-Video players
- [Raite](#): DVD-video players (Taiwan)
- Rankarena: DVD-Video players
- [RCA](#) (Thomson): DVD-video players
- RCR: DVD-Video players (China)
- REC: DVD-Video players (UK, made by [VDDV](#), same as APEX)
- Redstar: DVD-Video players
- [Revoy](#) (Netherlands): DVD-video players
- Roadstar: DVD-Video players
- Rotel: DVD-video players
- Rowa: DVD-Video players
- [Runco](#): DVD-video players and changers
- Saivod: DVD-Video players
- Sampo (Afreedy): DVD-Video players
- [Samsung](#): DVD-Video players

- Samwin: DVD-Video players
- [Sanyo](#): DVD-Video players
- SAST: DVD-Video players
- Schaub Lorenz: DVD-Video players
- Schneider: DVD-Video players
- Scott: DVD-Video players
- SEG (Yamakawa/Raite): DVD-Video players
- [Sharp](#): DVD-Video players
- [Shinco](#): DVD-Video players (Hong Kong)
- Shinsonic: DVD-Video players
- Singer: DVD-Video players
- Skyworth: DVD-Video players
- [SMC](#): DVD-Video players
- [Sonic Blue](#): DVD-Video players and combo DVD-VHS players (formerly Sensory Science and Go-Video)
- [Sony](#): DVD-Video players and changers
- Soyea: DVD-Video players
- [Spatializer Audio Laboratories](#): 3D audio processing
- [Sublime](#): DVD-Video players
- [Sylvania](#) (Funai): DVD-Video players
- [Symphonic](#) (Funai): DVD-Video players
- [Tatung](#): DVD-Video players
- [Teac](#): DVD-Video players
- [Technics](#) (Matsushita): DVD-Video and DVD-Audio players
- [Teknema](#) (Ravisent): Web-connected DVD-Video players
- Telestar: DVD-Video players
- Tevion: DVD-Video players
- [Thakral](#): DVD-Video players (China, Hong Kong)
- Theta: DVD-Video players
- [Thomson](#) (RCA/G.E./Proscan/Ferguson/Nordmende/Telefunken/Saba/Brandt): DVD-Video players
- Tokai (Raite): DVD-Video Players
- [Toshiba](#): DVD-Video players and recorders, DVD-Audio players
- TreDEX: DVD-Video players
- Umax: DVD-Video players
- United: DVD-Video players
- [Unity Motion](#): DVD-Video players

- Universum: DVD-Video players
- Venturer: DVD-Video players
- [Vialta](#) (ESS): WebDVD players
- [Victor](#) (JVC): DVD-Video players
- Vieta: DVD-Video players
- [Visual Disc and Digital Video](#): DVD-Video players (China)
- Waitec: DVD-Video players
- Walkvision: DVD-Video players
- Wharfedale: DVD-Video players
- Wintel: DVD-Video players
- XMS: DVD-Video players
- Xwave: DVD-Video players
- [Yamaha](#): DVD-Audio and DVD-Video players
- Yamakawa (Raite): DVD-Video players
- Yami (Raite): DVD-Video players
- Yelo: DVD-Video players
- Yukai: DVD-Video players
- [Zenith](#) (becoming a subsidiary of [LG](#)): DVD-Video players

[6.2.2] Studios, video publishers, and distributors

[DVD File](#) maintains a list of [studio addresses](#), as well as [DVD producer and distributor](#) information.

- [A2O Entertainment](#) (wholesale distributor)
- A.D. Vision (anime)
- Acorn Media
- [Aftermath Media](#) (*Tender Loving Care*, interactive movie)
- All Day Entertainment
- Alphaville Pictures (distributed by Universal)
- Amazing Fantasy
- Amblin Entertainment (distributed by Universal)
- American Gramophone
- American Software
- [Anchor Bay Entertainment](#)
- [Animeigo](#)
- A-Pix Entertainment
- [Artisan Home Entertainment](#) (formerly LIVE Entertainment)
- Arts & Entertainment DVD

- [Atomic Video](#) (adult)
- Avalanche
- [Baby Einstein](#) (infant development)
- Baker & Taylor (distributor)
- Beyond Music (distributor)
- [Black Chair Productions](#) (independent films)
- [Black Entertainment Television \(BET\)](#)
- BMG (Sonopress)
- Brentwood
- Brilliant Digital Entertainment (multipath movies)
- BroadcastDVD
- [Buena Vista Home Video](#) (Disney)
- [CAV Distributing](#) (distributor)
- [Castle Music Pictures](#) (music performance)
- [Castle Home Video](#)
- [Cecchi Gori](#)
- Celebrity
- [Central Park Media](#)
- [Cerebellum](#) (educational)
- Chesky
- Classic Records
- [Columbia TriStar](#) (Sony)
- [Compact Media](#) (distributor)
- Concert @ Home (Platinum Entertainment)
- Concorde Video (*12 Monkeys*, German)
- Corinth Films (Wade Williams Collection)
- Creative Design Art
- [Criterion Collection](#)
- [DaViD Entertainment](#)
- Delos International (mostly audio)
- Delta Entertainment
- Deluxe (distributor and replicator)
- DG Distributors (distributor)
- [Diamond Entertainment](#) (distributor)
- Digital Disc Entertainment

- [Digital Leisure](#) (formerly ReadySoft) (*Dragon's Lair*, *Space Ace*)
- Digital Multimedia
- [Digital Versatile Disc](#)
- [Dimension Films](#) (Miramax)
- Direct Source
- Direct Video Distribution (distributor, UK)
- [Disney](#) (Buena Vista Home Video, Dimension Films, Hollywood Pictures, Miramax, Touchstone)
- Dream Theater
- [DreamWorks SKG](#)
- [DVD International](#) (distributor)
- D-Vision
- Eaton Entertainment
- [Elite Entertainment](#)
- EMI Records
- E Real Biz
- Essex Entertainment
- [Fantoma](#)
- [Filmways](#) (distributor, Argentina/Spain)
- FOCUSFilm Entertainment
- Fox Lorber
- Front Row
- [Full Moon Pictures](#)
- Gainax (anime)
- General Media Communications (Penthouse) (adult)
- Goldhil Home Media
- [Goodtimes Entertainment](#)
- Gramercy Pictures (distributed by Universal)
- Hallmark Home Entertainment (Artisan)
- [HBO Home Video](#) (Warner)
- [HODIE](#) (multimedia recording label)
- [Hollywood Pictures](#) (Disney, folded into Touchstone)
- Hot Body International (adult)
- Ice Storm Entertainment (distributor, Germany)
- Ideal Entertainment
- [Image Entertainment](#) (distributor)

- Impressive (adult)
- [IndieDVD](#) (publisher; alliance of independent filmmakers)
- Ingram (distributor)
- Key East
- King's Road (distributed by Trimark)
- [Kino International](#)
- Laserdisc Entertainment (adult)
- Laserlight
- Lee & Lee Films
- Leo Films
- Living Arts (health)
- LucasFilm (distributed by Twentieth Century Fox or Paramount)
- [Lucerne Media](#) (educational)
- Lumivision (distributed by SlingShot)
- Lyric
- MacDaddy
- Madacy
- Magic Lantern
- [Marin Digital](#) (Your Yoga Practice)
- Master Tone
- [MCA](#) (Universal)
- MCA Music
- Media Galleries
- [Media Group](#) (distributor)
- Metro Global Media (adult)
- Metromedia
- [MGM/UA](#) (Warner)
- Mill Reef (*Earthlight*)
- [Miramax Films](#) (Disney)
- Monarch Home Video
- Monterey
- [MPI Home Video](#)
- MTI
- [Multimedia 2000](#) (aka M-2K)
- Music Video Distributors (distributor)

- N2K Music
- [Navarre](#) (distributor)
- [NET TEN](#) (distributor)
- Netzwerk Productions
- New Horizons Home Video
- [New Line](#) (Warner)
- New Video Group
- New Vision
- New York Entertainment
- NuTech Digital (adult)
- October Films (Universal)
- [Opera World](#)
- Orion Pictures (MGM, some older DVD titles distributed by Image and Criterion)
- [Overseas Filmgroup](#) (distributor, partner with Image)
- Pacific Digital
- [Palm Pictures](#)
- Panasonic Interactive Media (defunct)
- Panorama
- [Paramount Home Video](#) (owned by Viacom)
- Parasol
- Passport Video
- Phantom Video
- Picture This Home Video
- [Pioneer Entertainment](#) (distributor)
- Platinum
- [Playboy Home Video](#)
- PM Entertainment
- Polygram (Philips partner)
- Pony Canyon (Japan)
- PPI Entertainment
- [Private Media Group](#) (adult)
- Pro7 Home Entertainment (Germany)
- Program Power
- [Real Entertainment](#)
- Red Distribution (distributor)

- Renegade
- Republic Pictures (defunct, distributed by Artisan)
- [Rhino Home Video](#)
- Roadshow Entertainment (Australia)
- Roan Group
- Rykodisc
- Samsung Entertainment Group
- Shanachie
- Showtime
- [Simitar Entertainment](#)
- Sierra Vista Entertainment (Innovacom)
- Silver Screen
- [SlingShot](#) (acquired Lumivision titles)
- [Sony Music Entertainment](#)
- Sony Pictures (Columbia, Epic, Sony Music, Sony Wonder, TriStar)
- [Sony Wonder](#) (kids)
- Steeplechase
- [Sterling Home Entertainment](#)
- Super Digital Media
- [SyCoNet.com](#) (distributor, anime)
- [Synapse Films](#)
- [Tai Seng](#)
- [Technicolor](#) (distributor and replicator)
- [Tempe Entertainment](#)
- [Thakral](#) (distributor; Hong Kong, China)
- Toho (Japan)
- [Tone Home Video](#)
- Toshiba EMI
- [Touchstone](#) (Disney)
- [Trimark Pictures](#)
- [Troma Entertainment](#)
- Turner Home Entertainment
- [Twentieth Century Fox Home Entertainment](#)
- [Unapix Entertainment](#)
- United American

- United Artists (MGM)
- [Universal Studios Home Video](#) (owned by Seagram)
- USA
- U.S. Laser
- [Valley Media](#) (distributor)
- [VCA Interactive](#) (VCA Pictures, VCA Labs; adult)
- [VCI Home Video](#)
- Ventura
- Victor Entertainment (JVC)
- Victory
- Video Watchdog
- Video One Canada (distributor)
- Vidmark
- Vista Street
- [Vivid Video](#) (adult)
- [Walt Disney Pictures](#)
- Warner Bros. Records/Warner Music (Toshiba partner)
- [Warner Home Video](#) (Toshiba partner)
- Waterbearer Films
- [WIT Entertainment](#) (distributor)
- WGBH
- WWF Home Video
- Wolfe
- World Video
- Xenon
- Xoom
- York

[6.2.3] Hardware and computer components

- Acer Laboratories: DVD decoder/controller chips
- Advent: DVD-ROM-equipped computers
- Alliance Semiconductor: display adapters with hardware acceleration for DVD playback
- [Allion](#): DVD mirroring servers
- [AMLogic](#): DVD player chipset
- Analog Devices: 192-kHz/24-bit audio DAC

- [Apple](#): DVD-ROM- and DVD-RAM-equipped computers, playback hardware and software (QuickTime)
- [ASACA](#): DVD-RAM towers
- AST: DVD-ROM-equipped computers (with MMX-based playback software)
- ASM: DVD jukeboxes
- [ATI Technologies](#): display adapters with hardware acceleration for DVD playback
- Avid Electronics: DVD decoder/controller chips
- [Axis Communications](#): DVD-ROM storage servers
- [Bridge Technology](#): optical pickup assemblies
- Canopus: DVD-RAM video archiving.
- [CD Associates](#): Software and hardware for production and testing.
- CEI: DVD playback hardware and software
- [Cirrus Logic](#): MPEG-2 encoder/decoder chips
- [CMC Magnetics](#): recordable discs
- Compaq: DVD-ROM-equipped computers
- Creative Technology: DVD-ROM and DVD-RAM upgrade kits, DVD decoder software
- [Cygnet](#): DVD-RAM jukeboxes
- [DIC \(Dainippon Ink and Chemicals\)](#): ink, organic pigments, thermosetting resin
- [Dave Jones Design](#): controllers for industrial DVD players
- Diamond Multimedia: DVD upgrade kit (Toshiba drive)
- [Digimarc](#): watermarking technology
- Digital: DVD software playback (for Alpha workstations), DVD encoder chips
- [Digital Stream](#): optical pickup assemble
- Digital Video Systems: DVD-ROM drives
- [Disc, Inc.](#): DVD-RAM jukeboxes.
- DSM: DVD jukeboxes
- [DVDO](#): video deinterlacing chips
- DynaTek: DVD upgrade kit
- [EPO Technology](#): DVD-ROM drives
- [Escient](#): DVD-ROM changer
- ESS Technology: playback chipset, player reference design
- [Fantom Drives](#): DVD-RAM and DVD-ROM kits
- Fujitsu: DVD-ROM-equipped computers
- Gateway: DVD-ROM-equipped computers
- [Genesis Microchip](#): video chips (progressive-scan, scaling)
- [Granite Microsystems](#): IEEE-1394 DVD-ROM drives

- Harman Int.: DVD jukebox
- Hitachi: DVD-ROM drives, DVD-RAM drives, decoder chips
- Hi-Val: DVD playback hardware (upgrade kit)
- Hyundai: DVD decoder chips
- IBM: DVD-ROM-equipped computers, decoder chips
- [I-Jam](#): DVD-ROM drives
- [Imation](#): DVD-RAM media.
- Inaka: DVD jukebox software
- Infineon: DVD reader circuitry
- Innovacom: DVD encoder and decoder systems
- Intel: DVD playback hardware (MMX) and software
- [Interactive Seating](#): Battle Chair
- [I/OMagic](#): IEEE-1394 DVD-ROM drives
- JVC: DVD-ROM drives, DVD-RAM jukebox
- Kasan: decoder hardware
- [KOM](#): DVD-RAM changer
- [LaCie](#): DVD-RAM drives
- [Leitch](#): DVD-RAM video recording
- LG Electronics: DVD-ROM drives
- [LSI](#): DVD encoder and decoder chips (acquired C-Cube)
- [Luminex](#): Unix software for DVD-based archiving and duplication
- LuxSonor: DVD playback chips
- Margi: DVD decoder card for notebook PCs
- Matrox: display adapters with hardware acceleration for DVD playback
- Matsushita (Panasonic): DVD-ROM drives, DVD-RAM drives, upgrade kits, DVD/Web integration, DVD-RAM still-image recorder
- [Media100](#): DVD authoring tools, DVD playback hardware and software
- Mediamatics: DVD playback software and hardware
- Medianix: Dolby Digital decoder hardware with Spatializer 3D audio
- Memorex: DVD-ROM drives
- [Microboards](#): DVD drive (VAR)
- [Microsoft](#): DVD playback support (DirectShow) and player applications
- [Microtest](#): DVD-ROM jukeboxes
- Mitsubishi: DVD players, DVD-ROM drives
- Motorola: DVD decoder chips
- National Semiconductor: DVD playback and reference designs

- Number 9: display adapters with hardware acceleration for DVD playback
- [Nuon Semiconductor](#): DVD playback reference platform (Nuon)
- NEC: DVD-ROM drives
- [Net TV](#): DVD-ROM PC for home entertainment
- NSM: DVD-ROM jukebox, DVD-RAM jukebox
- Oak Technology: DVD playback hardware and software
- [OTG Software](#): DVD jukebox software
- Packard Bell: DVD-ROM-equipped computers
- Philips: DVD-ROM drives, DVD+RW drives, decoder chips
- Pioneer: DVD-ROM drives, DVD-R drives, DVD-RW video recorders
- Plasmon Data: DVD-RAM jukebox
- [ProAction Media](#): DVD duplication equipment
- Procom: DVD-ROM jukebox
- [Ricoh](#): DVD-ROM/CD-RW drives
- [Rimage](#): DVD duplication and printing equipment
- [RITEK](#): DVD-R, DVD-RAM
- S3: display adapters with hardware acceleration for DVD playback
- Samsung: DVD-ROM drives and DVD-ROM-equipped computers
- [Spectradisc](#): limit-play technology
- [STMicroelectronics](#) (formerly SGS-Thomson): DVD decoder chips
- SIKAN: DVD decoder chips
- [Sigma Designs](#): DVD playback hardware
- [Software Architects](#): DVD-recordable utilities for UDF and Mt. Rainier writing
- [Sonic Solutions](#): DVD-Video decoding software (acquired portion of Ravisent, formerly Quadrant International)
- [Sony](#): DVD-ROM drives, DVD-ROM-equipped computers
- [ST Microelectronics](#): DVD decoder chips (acquired portion of Ravisent, formerly Quadrant International)
- STB Systems: DVD playback hardware (upgrade kit)
- [Technovision](#): Controllers and synchronizers for consumer and industrial DVD players
- TDK: blank DVD-RAM discs
- Toshiba: DVD-ROM drives, DVD-ROM-equipped computers, DVD-RAM drives
- [Tracer Technologies](#): DVD jukebox software and DVD recording software (Unix)
- [TribeWorks](#): custom player software
- Trident Microsystems: DVD decoder chips, DVD-accelerated video controller chips
- Truevision: DVD playback software (Microsoft Active Movie 2.0)

- Verbatim Australia (ActiveMedia): DVD playback hardware (upgrade kit)
- [VisionTech](#): MPEG-2 encoder/multiplexer
- [Wired](#): DVD playback hardware and software (acquired by Media 100)
- [X-10.com](#): (wireless DVD transmitter)
- [Xing](#): DVD playback software
- Yamaha: AC-3 decoder chips
- Zen: multi-beam DVD reading technology
- Zoran/CompCore: DVD software and hardware playback, DVD decoder chips

[6.2.4] Computer software titles on DVD-ROM

- 2 Way Media: Launch
- [Access Software](#): Overseer, Tex Murphy
- [Acclaim Entertainment](#): Reah
- Accolade: Jack Nicklaus 4, Family Spectacular
- [Action Zone](#): games
- Activision (Quicksilver): Muppet Treasure Island, Spycraft: The Great Game, Zork: The Grand Inquisitor
- [Aftermath Media](#): Tender Loving Care
- ALLDATA: automotive information databases
- [Aludra](#): Beat 2000 DVD, Language Tutor DVD, Virtual Makeover DVD
- [Apple Computer](#): Mac OS Anthology (available to developers only)
- BBC Interactive
- [Black Isle Studios](#) (Interplay): Baldur's Gate
- [Broderbund](#): Riven, PrintMaster Platinum, ClickArt 300,000.
- [Byron Preiss](#)/Simon & Schuster: The Timetables of Technology
- [ComChoice](#): Marketing, sales, and training
- [Creative Multimedia](#): Billboard Music Guide, Blockbuster Entertainment Guide to Movies and Video
- [Creative Wonders](#) (The Learning Company): Schoolhouse Rock, Sesame Street, Wide World of Animals
- [DeLorme](#): AAA Map'n'Go DVD Deluxe
- Data Becker: Clipart Collection, Sound Collection
- [Digital Directory Assistance](#): PhoneDisc PowerFinder USA One
- [Digital Versatile Disc](#): Shaodan
- [Digital Leisure](#): Dragon's Lair, Hologram Time Traveler, Space Ace
- [Discovery Channel](#): Leopard Son/Animal Planet, Connections
- [Dorling Kindersley](#)
- [Electronic Arts](#): Wing Commander IV

- Electronic Publishing Association: LANGMaster Collins COBUILD Student Dictionary
- [EuroTalk Interactive](#): Language Learning
- [Firebrand](#): Lost in Crazy Town
- [genX Software](#): Dead Moon Junction
- [Global Star Software](#): 100 Great Action Arcade Games, Excessive Speed, Gubble, 303 Professional Legal Forms
- Graphix Zone
- Grolier: Multimedia Encyclopedia
- GT Entertainment: Forrest Gump, Reah
- [Hachette Multimedia](#): Hachette Encyclopedia
- IBM Interactive Media: The Pistol: The Birth of a Legend
- [Index+](#): Dracula Resurrection, Dracula the Last Sanctuary, Louvre the Final Curse
- [Interactual Technologies](#): Star Trek VideoSaver
- [Interplay](#): Baldur's Gate, Starfleet Academy
- [Into Networks](#): PlayNow (unlockable games)
- IVS: The Union Catalogue of Belgian Research Libraries
- Japan Travel Bureau: DVD-Web product
- [Kunskapsforlaget](#) (Sweden): Focus Encyclopedia
- The Learning Company (SoftKey): Battles of the World, Clickart, Digital Library, The Genius of Edison, National Geographic, Printmaster 7.
- Liris (Havas) Interactive: Découvertes (Junior Discovery)
- [Magnum Design](#)
- Mechadeus: The Daedalus Encounter
- [MediaGalleries](#): Multimedia Bach
- [MediaOne](#): VersaDisc
- [Microsoft](#): Encarta, MSDN/TechNet, Works Suite
- [Mill Reef](#): Earthlight, Coral Sea Dreaming
- [Mindscape](#)
- [Mitchell Repair Information Company](#): ON-DEMAND
- [Monolith](#): Claw
- [Montparnasse Multimedia](#): Microcomsos, Voyage to the land of the Pharaohs
- [Multimedia 2000](#) (aka M-2K, formerly Multicom): Birds of the World; Bubblegum Crisis; HomeDepot's Home Improvement 1-2-3; Warren Miller's Ski World '97; Exploring National Parks; Great Chefs, Great Cities; Better Homes and Gardens Cool Crafts
- [Natif](#)
- [NB Digital](#)/[Mill Reef](#): Earthlight
- [Not A Number](#): Blender

- [Oeil Pour Oeil](#): Death Dealer
- [Organa](#): The Book of Lulu
- [Pro CD](#): Select Phone
- [Project Two Interactive](#): Reah (distributed by GT in U.S., Acclaim in UK and Ireland)
- [Psygnosis](#): Lande
- Red Orb Entertainment:
- [Sega](#): 4 game/instruction titles to be released in early 1997
- [Sierra Online](#)
- [Sumeria](#): Vanishing Wonders of the Sea, Wild Africa
- SuperZero: adult DVD-Video
- [SuSE](#): SuSE Linux 6.3
- [TerraGlyph Interactive Studios](#): Buster and the Beanstalk (Tiny Toons)
- [Torus Games](#)
- Tsunami: Crazy 8's, Silent Steel, Silent Steel II
- [VR Sports](#) (Interplay): Virtual Pool
- Warner Advanced Media
- Westwood Studios: Command & Conquer
- [Xiphias](#): Encyclopedia Electronica
- Zombie VR Studios: Liberty

[6.3] Where can I buy (or rent) DVDs and players?

(See [1.8](#) for price comparisons and coupons.)

- [800.com](#) (players)
- [999Central](#) (DVDs for shipping and handling cost only)
- [A&B Sound](#) (Canada)
- [abcDVD](#) (UK, region 1)
- [abt Electronics](#) (players)
- [AccessDVD.com](#)
- [Ace VCD DVD](#) (Hong Kong/anime)
- [Airplay](#) (Japan, region 2)
- [All DVD Movies](#) (DVDs)
- [AllCheapMusic.com](#) (DVDs for \$10 or less)
- [Amazon.com](#) (players and DVDs)
- [Amazon.co.uk](#) (UK; players and DVDs)
- [AnimeNation](#) (DVDs)
- [Anime Depot](#) (DVDs)

- [Asian Xpress](#) (Hong Kong films)
- [Atlantic DVD](#) (region 4)
- [Bargainflix](#) (DVDs)
- [Best Buy](#) (players and DVDs)
- [Best Buy Movie](#) (Germany; DVDs)
- [BestPrices.com](#) (DVDs)
- [Bensons World](#) (UK; players)
- [Beyond Music](#) (DVDs)
- [Big Emma](#) (used DVDs)
- [BigStar](#) (players and DVDs)
- [BigWheelOnline.com](#) (DVDs; \$1 shipping worldwide)
- [BlackStar](#) (UK, region 2 DVDs; free shipping worldwide)
- [Blockbuster](#) (rental and sales of DVDs)
- [Brainplay.com](#) (DVDs)
- [Buy.com](#) (players and DVDs)
- [CashForCDs.com](#) (sell your used DVDs and CDs)
- [C&L Internet Club](#) (Canada; DVDs)
- [CD JAPAN](#) (Japan, region 2)
- [CDNOW](#) (DVDs)
- [CDRealm](#) (Switzerland)
- [Columbia House](#) (DVD mailorder club)
- [Consumer Direct Warehouse](#) (players)
- [Critics' Choice Video](#) (DVDs)
- [DeepDiscountDVD.com](#) (DVDs)
- [DeVoteD](#) (Australia, region 4 DVDs)
- [Digibuster Media](#) (online rental)
- [Digital Entertainment](#) (Indian films)
- [Digital Eyes](#) (DVDs)
- [Digital Playtime](#) (Australia, region 4)
- [Digitallageret.com](#) (Asian imports)
- [The Digital Shop](#) (Greece)
- [Direct Video](#)
- [Disc and Picture Company](#) (Australia)
- [discShop.com](#) (UK, region 1 and 2)
- [DVDCity](#)

- [DVD City](#) (Australia)
- [DV Depot](#)
- [DVD Domain](#)
- [DVD Empire](#)
- [DVDIt Italia](#) (Italy)
- [DVD North](#) (Canada)
- [DVDONE](#)
- [DVD Overnight](#) (online rental)
- [DVD Palace](#) (formerly Liquidata)
- [DVD Planet](#) (formerly Ken Crane's, now a division of Image Entertainment)
- [DVDPlus](#) (Europe)
- [DVD Rent](#) (Australia, sales and online rental)
- [DVDshoppingCenter](#) (region 2)
- [The DVD Movie Store](#) (Australia, offline rentals)
- [DVDstreet](#) (region 2)
- [DVD Supercenter.com](#) (adult)
- [DVD titlewaves](#) (discs and players)
- [DVD VideoPlanet](#) (New Zealand, regions 1 and 4)
- [DVD Wave](#)
- [DVD World](#) (UK, region 2)
- [DVD World](#) (New Zealand, regions 1 and 4)
- [DVD Zone 2](#) (region 2)
- [eBay](#) (buy and sell new and used DVDs)
- [Elvic](#) (Netherlands)
- [EntertainmentStudios.com](#) (DVDs)
- [Evolution Audio & Video](#)
- [Express.com](#)
- [Fantastic Movies](#) (Switzerland)
- [FeatureDVD](#)
- [Fotosound](#) (UK)
- [Gamestech.com](#) (multi-region players)
- [German Music Express](#) (Germany)
- [GreenCine](#) (online rental of rare and alternative titles)
- [Just Watch It](#) (regions 1 and 2)
- [Karaoke - Show](#) (Switzerland)

- [LADA Universal](#) (regions 1 and 2, new and used)
- [Laser Corner](#) (Greece)
- [Laserdisc DVD Outlet](#)
- [Laser Discovery](#) (online rental, Hong Kong movies)
- [The LaserDisc Division](#)
- [Laserdisc House](#) (UK, regions 1 and 2)
- [Laser's Edge](#)
- [Laservisions Direct](#)
- [LearningStore.co.uk](#) (educational and non-violent DVDs)
- [GoDVD](#) (UK, regions 1 and 2)
- [Half.com](#) (used discs and players)
- [Hastings Entertainment](#) (buy or rent DVDs)
- [Hifi.com](#) (players)
- [HKFlix.com](#) (Asian DVDs)
- [InsideDVD](#) (free disc subscription)
- [Hollywood Video](#) (rental)
- [Ken Crane's](#)
- [Kotiteatteri](#) (Finland)
- [Media Play](#)
- [MegaDVD](#)
- [MovieClubOnline](#) (discount video rentals)
- [MovieGallery.com](#) (new and used movies and games)
- [Musicland](#)
- [NetFlix](#) (online rental, monthly fee)
- [North American DVD](#) (retail and wholesale)
- [On Cue](#)
- [OneCall](#) (players)
- [OZDVD Warehouse](#) (region 4)
- [Reel.com](#) (no longer sells discs)
- [Reg2.net](#) (Spain)
- [RegionFreeDVDPlayers](#)
- [Rent A DVD](#) (online rental, Switzerland)
- [Ro-Disc](#) (Netherlands, regions 1 and 2)
- [Sam Goody](#)
- [Second Chance DVD](#) (used)

- [Shopping.com](#)
- [Shopping Matrix](#) (South Africa, region 2)
- [Sony Music Direct](#)
- [Stardust DVD](#) (Puerto Rico)
- [Starship Industries](#)
- [SublimeDigital.com](#) (players and drives)
- [SVS](#) (UK, region 2)
- [Swinging Planet](#) (UK, cult video; region 2)
- [TLA Video](#)
- [Trans World Entertainment \(TWEC\)](#)
- [Universe of Entertainment](#) (Switzerland)
- [VideoCave](#)
- [VideoLtd.com](#)
- [Virgin Megastore](#)
- [ZoneFreeDVD](#)
- [Xchangeconomy](#) (trade DVDs with other members)

(Disclosure: Some of the links above include affiliate program information that may result in a commission to Jim.)

6.3.1 Where can I buy blank recordable DVDs?

Important note: With blank DVDs the adage "you get what you pay for" is usually true. Cheaper discs are more likely to produce errors when burning and are less compatible with players.

- [800 CDR](#)
- [American Recordable Media](#)
- [Buy-DVD-R.com](#)
- [CD-DVD-Supplies.com](#)
- [CD-Recordable.com](#)
- [CDROM2Go.com](#)
- [dvdr.co.uk](#)
- [J&R Electronics](#)
- [Meritline.com](#)
- [Memorex](#)
- [ProAction Media](#)
- [Pro Tape Northwest](#)
- [Shop4tech.com](#)

[6.4] Where can I get more information about DVD?

[6.4.1] A few of the top DVD info sites

- The Digital Bits <www.thedigitalbits.com> (top DVD news site)
- DVDFile <www.dvdfile.com> (another good DVD news site)
- DVD Review <www.dvdreview.com> (DVD news and production information)
- DigitalAudioVideo.com <<http://www.digitalaudiovideo.com>> (DVD tech support)
- DVDAnswers <www.dvdanswers.com> (general DVD info site)
- Home Theater Forum <www.hometheaterforum.com> (general DVD discussions)
- TheDVDPlayer <www.thedvdplayer.com> (immense collection of links to other DVD pages)
- Chad Fogg's DVD technical notes <www.mpeg.org/~tristan/MPEG/DVD/> (from 1996)
- Quantel Digital Fact Book (digital video info and glossary) <www.quantel.com/dfb>
- DVD for not-so-Dummies, from Technicolor <www.technicolor.com/services/DVD2000v1.pdf>
- DVD White Papers, from Sonic Solutions <www.sonic.com/tech_whitepapers.html>
- Discronics' (Graham Sharpless's) DVD Technology pages <www.discusa.com/dvd/dvdmain.htm>
- Tristan's MPEG Pointers and Resources <www.mpeg.org>
- DVD discussion list. Send "subscribe DVD-L <your name>" to listserv@listserv.temple.edu
- For details on YUV, RGB, YCbCr, etc., read Charles Poynton's [Color FAQ](#) (or buy his [book](#)).
- Robert's DVD Info <www.robertsdvd.com> (the granddaddy DVD link page, not updated recently)

[6.4.2] DVD utilities and region-free information

(See [1.10](#) for more information about regions.)

- DVD Infomatrix <www.inmatrix.com> (a wealth of information about DVD PCs)
- MPEGX <www.mpegx.com> (PC utilities for video and audio, more)
- DVDSOFT.net <www.dvdsoft.net> (PC utilities, more)
- Doom9 <www.doom9.net> (PC utilities for DVD backup)
- Visual Domain <www.visualdomain.net> (PC utilities, including *Drive Info*)
- DVDCity <www.dvdcity.com/codefree/codefree-dvd-info.html> (code-free DVD player FAQ)
- Code Free DVD <www.codefreedvd.com> (region-free DVD players)
- Code Free DVD Mart <www.codefreedvdmart.com> (region-free DVD players and information)
- Region Free DVD <www.regionfreedvd.net> (region workarounds for players and PCs)
- RegionFreeDVDPlayers <regionfreedvdplayers.com> (region-free DVD players)
- ZoneFreeDVD <zonefreedvd.com> (region-free DVD players)
- dvdkits.com <www.dvdkits.com> (modification chips for DVD players)
- DVD Upgrades <www.dvdupgrades.ch> (region-free DVD players and modification chips)
- DVDoverseas <www.dvdoverseas.com> (region-free DVD players)
- Link Electronics <www.linkonline.co.uk> (region-free DVD players and upgrades)
- Techtronics <www.techtronics.com> (region-free DVD players and upgrades)
- Upgrade Heaven <www.homecinemaheaven.com> (region-free DVD players)

- Eric's DVD Information <www.brouhaha.com/~eric/video/dvd> (tech info on early players)
- Google Deja Usenet Archive <www.deja.com> (search the rec.video.dvd and alt.video.dvd newsgroups)
- The Mac DVD Resource <www.wormintheapple.gr/macdvd/?action=intro> (region-free info for Macs)
- RipDifferent Forum <www.ripdifferent.com> (discussion of audio and video ripping on Macs)
- PowerBook DVD Source <<http://www.dfbills.com/powerbook/dvd.html>> (info about DVD on Macs)

[6.4.3] Information and discussion groups for DVD authors

- DVD Made Easy <dvdmadeeasy.com> (tutorials, forums, and other resources; fee-based)
- EZ DVD Advisor <www.ezdvdadvisor.com> (forums and other resources)
- DVD Developer Club at Yahoo <clubs.yahoo.com/clubs/dvddeveloper> (discussion of authoring techniques and problems)
- TFDVD <tfdvd.com> (subscription side, mostly focused on Apple *DVD Studio Pro*)

[6.4.4] DVD info for specific regions

- uk.media.dvd FAQ <www.dvdreviewer.co.uk/umdvdfaq/>
- UK DVD FAQ <movieuk.com/dvdfaq.htm> (not updated since 12/98)
- DVD Debate <www.dvddebate.com> (news, info, and user discussions; mainly region 2)
- DVD Times <www.dvdtimes.co.uk> (news, info, and reviews; mainly region 2)
- DVD Reviewer <www.dvdreviewer.co.uk> (news, info, and reviews; mainly UK)
- DVDLink <www.dvdlink.co.uk> (news and links to hundreds of other DVD sites)
- [Michael D's Region 4 DVD Info Page](#) (reviews and other info on region 4 discs)

[6.4.5] DVD info in other languages

- DVDUpdate <www.dvdupdate.nl> (Dutch)
- DVDEnFrancais <www.dvdenfrancais.com> (French, Canada)
- dvdfr.com <www.dvdfr.com> (French)
- Area DVD <www.areadvd.de> (German)
- DVD-Inside <www.dvdinside.ch> (German)
- DVDPrime <www.dvdprime.com> (Korean)
- dvdnett.no <www.dvdnett.no> (Norwegian)
- DVD'mension <dvd.wp.pl> (Polish)
- DVDSpecial <www.dvdspecial.ru> (Russian)
- Audio Video Cine en Casa <club.idecnet.com/~modegar/> (Spanish)

[6.4.6] Books about DVD

- [DVD Demystified](#), by Jim Taylor (the author of this FAQ)
- [DVD Authoring and Production](#), by Ralph LaBarge
- [Desktop DVD Production](#), by Douglas Dixon

- [From VHS to DVD](#), by Mark-Steffen Goewecke
- [CD-R/DVD Disc Recording Demystified](#), by Lee Purcell
- [DVD Production](#), by Phil De Lancie and Mark Ely

[6.5] What's new with DVD technology?

November 2004

New Medium Enterprises announced yet another contender for next-generation DVD: VMD (Versatile Multilayer Disc), to be launched in fall 2005, which adds additional layers to standard 1- or 2-layer DVDs to store 15, 20, 25, and 30 GB on a disc. I'll say what I said about FMD (an intriguing technology that failed): dozens of high-powered companies defined the DVD standard. Small startups with great ambitions but limited resources will never succeed in creating a mass-market successor.

August 2004

Both the DVD-Forum and the Blu-ray Disc Association (BDA) have chosen VC-1 (Microsoft's WMV9) and H.264 as advanced video codecs.

November 2003

On November 19th the DVD Forum steering committee finally approved the blue-laser HD-DVD standard for continued work.

The Chinese government announced that EVD (enhanced versatile disc) would be launched for Christmas 2003. EVD is a "homegrown" alternative to DVD technologies developed by the DVD Forum and CE companies in Japan. EVD uses its own optical disc format and a proprietary video compression technology (VP5 and VP6, developed by On2 in the U.S.). EVD supports HD resolutions up to 1920x1080. EVDs will not play in standard DVD players, and it's possible that many EVD players will not play DVDs since part of the reason for developing the format was to get away from paying royalties on DVD technologies. EVD players in China will cost about \$250, compared to about \$80 for a DVD player. It remains to be seen if EVD will succeed in China and if it will appear in any other countries.

September 2003

The DVD Forum steering committee once again failed to approve the AOD format (now being called HD-DVD by proponents in the DVD Forum). Some people in the industry, including Warren Lieberfarb, formerly at Warner and responsible for much of the success of DVD, began talking about sticking with existing red-laser DVD for high-definition video, using advanced codecs such as H.264 or Microsoft WM9. A number press articles incorrectly reported that the DVD Forum was abandoning blue-laser HD technology.

June 2003

There are rumors that there's a 6th HD format in the works based on the +RW format.

In the June meeting of the DVD Forum Steering Committee, the vote to officially approve work on the next-generation DVD format (AOD, see below) did not pass. This does not mean that the format was voted down, as reported elsewhere, only that the proposal as currently defined was not approved. There was clear bias in the voting, since the members that voted no or abstained were all participants in the competing Blu-ray group. There will be another vote on a modified proposal in mid September. In the meantime, work continues inside and outside the DVD Forum on next-generation DVD.

March 2003

There are now at least 5 candidates for high-definition DVD. (See [3.13](#) for details).

1. HD-DVD-9 (aka HD-9).
2. Advanced Optical Disc (AOD).
3. Blu-ray (BD).
4. Advanced Optical Storage Research Alliance (AOSRA), Blue-HD-DVD-1.

June 2002

Philips demonstrated a blue-laser miniature pre-recorded optical disc. The 3-cm (1.2-inch) disc holds 1 Gbyte of data. The prototype drive to read the disc measured 5.6 x 3.4 x 0.75 cm (2.2 x 1.3 x 0.3 inches).

February-March 2002

A group of 9 companies announced February 19th a new high-density recordable DVD standard, known as Blu-ray. At the DVD Forum general meeting in March, the Forum announced that it will investigate next-generation standards to choose the best one. Since the 9 companies are all members of the DVD Forum, it's likely that Blu-ray will eventually be approved by the Forum.

Also at the March meeting the Forum announced that according to AOL Time Warner's request it will work on a standard for putting high-definition video on existing DVDs. The format is being called "HD-DVD-9." See [3.13](#).

[7] Leftovers

[7.1] Unanswered questions

None at the moment.

[7.2] Notation and units

There's an unfortunate confusion of units of measurement in the DVD world. For example, a single-layer DVD holds 4.7 billion bytes (G bytes), not 4.7 gigabytes (GB). It only holds 4.37 gigabytes. Likewise, a double-sided, dual-layer DVD holds only 15.90 gigabytes, which is 17 billion bytes.

The problem is that the [SI](#) prefixes "kilo," "mega," and "giga" normally represent multiples of 1000 (10^3 , 10^6 , and 10^9), but when used in the computer world to measure bytes they generally represent multiples of 1024 (2^{10} , 2^{20} , and 2^{30}). Both Windows and Mac OS list volume capacities in "true" megabytes and gigabytes, not millions and billions of bytes

Most DVD figures are based on multiples of 1000, in spite of using notation such as GB and KB that traditionally have been based on 1024. The "G bytes" notation does seem to consistently refer to 10^9 . The closest I have been able to get to an unambiguous notation is to use "kilobytes" for 1024 bytes, "megabytes" for 1,048,576 bytes, "gigabytes" for 1,073,741,824 bytes, and "BB" for 1,000,000,000 bytes.

This may seem like a meaningless distinction, but it's not trivial to someone who prepares 4.7 gigabytes of data (according to the OS) and then wastes a DVD-R or two learning that the disc really holds only 4.3 gigabytes! (See [3.3](#) for a table of capacities.)

Here's an analogy that might help. A standard mile is 5,280 feet, whereas a nautical mile is roughly 6,076 feet. If you measure the distance between two cities you will get a smaller number in nautical miles, since nautical miles are longer. For example, the distance from Seattle to San Francisco is about 4,213,968 feet, which is 798 standard miles but only 693 nautical miles. DVD capacities have similarly confusing units of measurement: a billion bytes (1,000,000,000 bytes) or a gigabyte (1,073,741,824 bytes). DVD capacities are usually given in billions of bytes, such as 4.7 billion bytes for a recordable disc. Computer files are measured in gigabytes. Unfortunately, both types of measurements are often labeled as "GB." So a 4.5-GB file (4.5 gigabytes) from a computer will not fit on a 4.7-GB disc (4.7 billion bytes), since the file contains 4.8 billion bytes.

To make things worse, data transfer rates when measured in bits per second are almost always multiples of 1000, but when measured in bytes per second are sometimes multiples of 1024. For example, a 1x DVD drive transfers data at 11.08 million bits per second (Mbps), which is 1.385 million bytes per second, but only 1.321 megabytes per second. The 150 KB/s 1x data rate commonly listed for CD-ROM drives is "true" kilobytes per second, since the data rate is actually 153.6 thousand bytes per second. This FAQ uses "kbps" for thousands of bits/sec, "Mbps" for millions of bits/sec (note the small "k" and big "M").

In December 1998, the [IEC](#) produced new prefixes for binary multiples: kibibytes (KiB), mebibytes (MiB), gibibytes (GiB), tebibytes (TiB), and so on. (More details at [NIST](#), also released as [IEEE](#) Std 1541-2002) These prefixes may never catch on, or they may cause even more confusion, but they are a valiant effort to solve the problem. The big strike against them is that they sound rather silly.

[7.3] Acknowledgments

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[End]