

spaces between the endothelial cells lining the local capillaries (Bangham, 1992; Ostro, 1992). Encapsulation of drugs in liposomes thus results in an increase of drug levels at the targeted sites when compared with the conventional formulations. This site-specific action reduces the toxicity of drugs without loss of their efficacies, and has been used to improve the therapeutic indices of several classes of drugs. For example, the liposome formulation of Amphotericin B, an antifungal agent with serious toxicity, has been proven to be as much as 70 times less toxic in mice than the conventional formulation. Similarly, the serious irreversible cardiomyopathy side effect of doxorubicin, a widely used anticancer drug, can be reduced using liposome technology.

## MARKETED PRODUCTS AND CLINICAL TRIAL PROJECTS

With the development of the liposome technology, more and more marketed products and clinical trial projects have been developed. Table 14.1 summarizes marketed liposomal products, and Table 14.2 give a representative list of products that are in clinical trials as liposomal formulations.

AmBisome<sup>®</sup>, a liposomal formulation of Amphotericin B developed by Nexstar (now Gilead Sciences), has been approved for use in more than 40 countries since 1990 and was approved for the U.S. market by the Food and Drug Administration (FDA) in 1997. Several other forms of liposomal

**TABLE 14.1**  
**Marketed Liposomal Products**

Drug	Product Name	Company*	Route	Drug Activity	Status	References
Doxorubicin	Doxil	Alza/Janssen	IV	Cancer	Marketed	PDR (2006)
	Myocet	Cephalon	IV	Cancer	Marketed (EU)	Allen and Cullis (2013)
Amphotericin B	Ambisome	Gilead/Astellas	IV	Antifungal	Marketed	PDR (2006)
	Abelcet	Liposome Co./Sigma-Tau	IV	Antifungal	Marketed	PDR (2006)
Daunorubicin	Amphotec	Alza/Three Rivers	IV	Antifungal	Marketed	Dupont (2002)
	DaunoXome	Gilead/Galen US	IV	Cancer, Kaposi's Sarcoma	Marketed	Allen and Cullis (2013)
Cytarabine	DepoCyt	SkyePharma/Sigma-Tau	Intrathecal	Lymphomatous meningitis	Marketed	PDR (2006); Dupont (2002)
Morphine sulfate	Depodur	SkyePharma/Pacira	Epidural	Pain	Marketed	PDR (2006); Dupont (2002)
Verteporfin	Visudyne	QLT/Valeant	IV	Age related macular degeneration	Marketed	PDR (2006); Dupont (2002)
Vincristine	Marquibo	Talon	IV	Leukemia	Marketed	PDR (2006); Dupont (2002)
Bupivacaine	Exparel	Pacira	Surgical site	Anesthesia	Marketed	Allen and Cullis (2013) Viscusi et al. (2014); PDR (2006); Dupont (2002)
Muramyl tripeptide PE	Mepact; Junovan	IDM pharma	IV	Osteosarcoma	Marketed (EU) NDA (US)	Nardin et al. (2006)
Irinotecan hydrochloride	Onivyde	Merrimack pharmaceuticals	IV	Cancer	Marketed	PDR (2006)
Paclitaxel	Lipusu	Luye pharma	IV	Cancer	Marketed (China)	PDR (2006)

PDR: Physician's Desk Reference.