Hosseinzadeh 2008). These alkaloids include berberine, berberamine, canadine, columbamine, corypalmine, jatrorrhizine, and palmatine. Berberine is identical with umbellatine and chemically related to hydrastine. Hydrastinine is a decomposition product of either berberine or hydrastine. Although these alkaloids are similar in structure, they differ in the effects they produce. In general, protoberberine alkaloids relax smooth muscle, causing a transient decrease in blood pressure and inhibition of acetylcholinesterase (Southon and Buckingham 1989). Berberine may cause seizures in higher dosage and also inhibits enzymes such as tyrosine decarboxylase and tryptophanase. The specific agent responsible for the therapeutic action of *B. aquifolium* on psoriasis is not known (Hansel 1992). Studies in rats indicate hepatic effects such as protective actions against liver damage from acetaminophen and inhibition of cytochrome P450 microsomal drug-metabolizing enzymes (Janbaz and Gilani 2000). Prolongation of pentobarbital sleeping time and increased strychnine intoxication effects suggest the potential for interaction with the activity of a variety of drugs and toxicants (Figures 14.2 and 14.3).

nausea, vomiting, diarrhea; gross pathology, mild reddening of the digestive tract; treatment not needed; use of berberine products during pregnancy may cause uterine contractions

Clinical Signs, Pathology, and Treatment—Signs of *Berberis* intoxication reflect mild to moderately severe irritation of the digestive tract and include nausea, vomiting, and diarrhea. Additionally, there may be decreased blood pressure and dyspnea. The results of ingestion are generally mild, not lethal; thus treatment, if needed at all, is limited to temporary relief of the diarrhea. Usage of berberine or related products should be avoided in pregnancy because of their potential for causing uterine contractions and possibly miscarriage (Imanshahidi and Hosseinzadeh 2008).

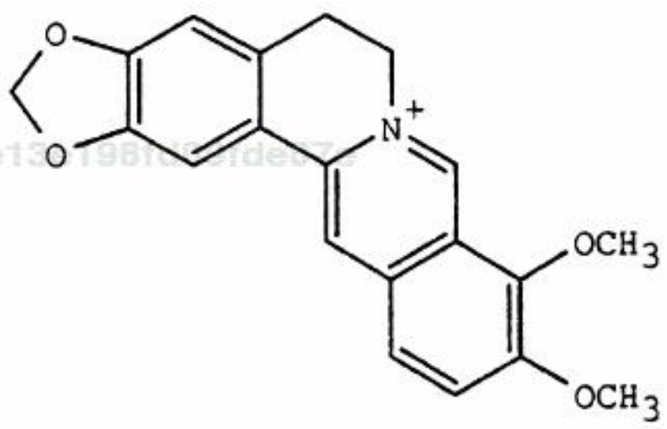

Figure 14.2. Chemical structure of berberine.

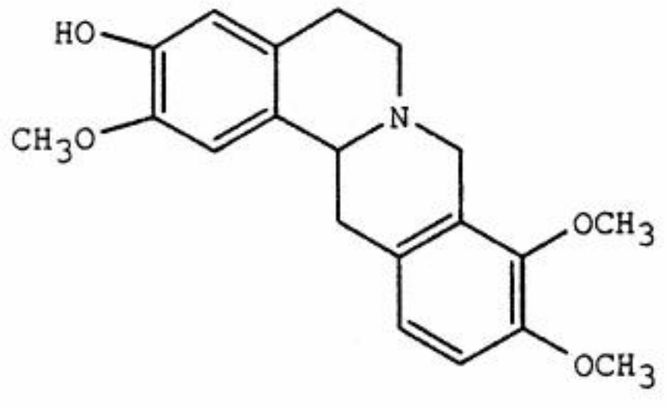

Figure 14.3. Chemical structure of corypalmine.

MAHONIA

See treatment of *Berberis* in this chapter.

NANDINA THUNB.

Taxonomy and Morphology—*Nandina*, a monotypic genus native to China and Japan, gets its name from *nandin*, the Japanese common name for the species or the Chinese name meaning "plant from the south" (Huxley and Griffiths 1992; Whittemore 1997). With more than 60 highly esteemed cultivars, the single species is as follows:

N. domestica Thunb. heavenly bamboo, nandina, Chinese sacred bamboo

erect shrubs, reddish branchlets; leaves 3-pinnately compound, alternate, red purple in winter; flowers numerous, tiny, cream to white; berries red to purple red in winter

Plants shrubs; evergreen or semideciduous. **Stems** erect; clumped; typically not branched; 100–200 cm tall; branchlets reddish. **Leaves** 2- or 3-pinnately compound; alternate; leaflet blades elliptic to lanceolate to ovate, turning red purple in winter; margins entire; petiole bases clasping. **Inflorescences** terminal or axillary panicles; erect or arching. **Flowers** small; numerous. **Sepals and Petals** intergrading; cream to white. **Stamens** 6. **Berries** globose; red to purple red. **Seeds** 1–3; grayish or brownish (Figures 14.4 and 14.5).

Distribution and Habitat—Very common and widely cultivated throughout North America, *N. domestica* is quite tolerant of a variety of environmental conditions and is prized for its winter foliage of reddish purple leaves and red berries.

cyanogenic glycosides, peracute intoxication, ruminants, pets, rare; protoberberine alkaloids; serotonin antagonist, nantenine

Figure 14.4. Illustration of *Nandina domestica.*

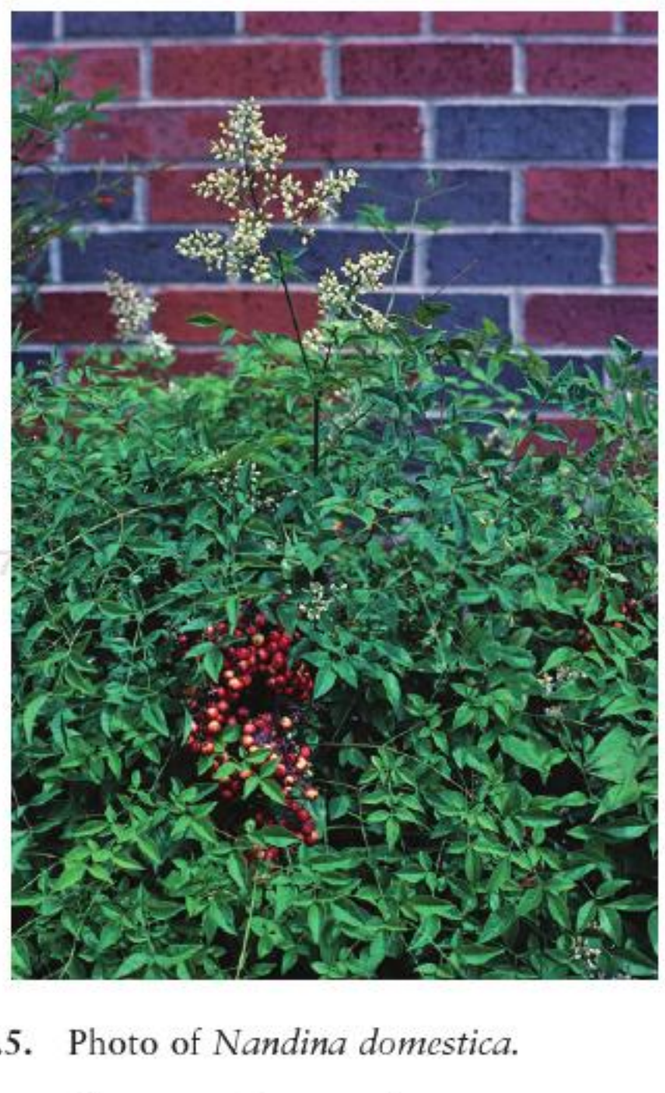

Figure 14.5. Photo of *Nandina domestica.*

Disease Problems and Genesis—Many but not all cultivars of *Nandina* are strongly cyanogenic and represent a hazard to ruminants that gain access to them. Occasionally, other animals, such as puppies, may be at risk (Bradley et al. 1988). Cyanogenesis is due to the glucosides *p*-hydroxymandelonitrile and *p*-glucosyl-oxymandelonitrile, which are derived from phenylalanine and tyrosine, respectively. Under the appropriate conditions in the plant or rumen, they subsequently are hydrolyzed to the aglycone or sugar-free glycone and then to free HCN (Seigler 1977) (Figures 14.6 and 14.7).

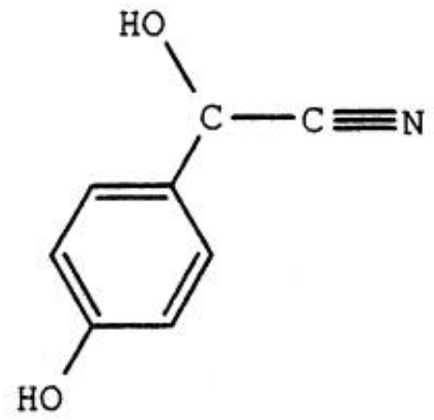

Figure 14.6. Chemical structure of *p*-hydroxymandelonitrile.

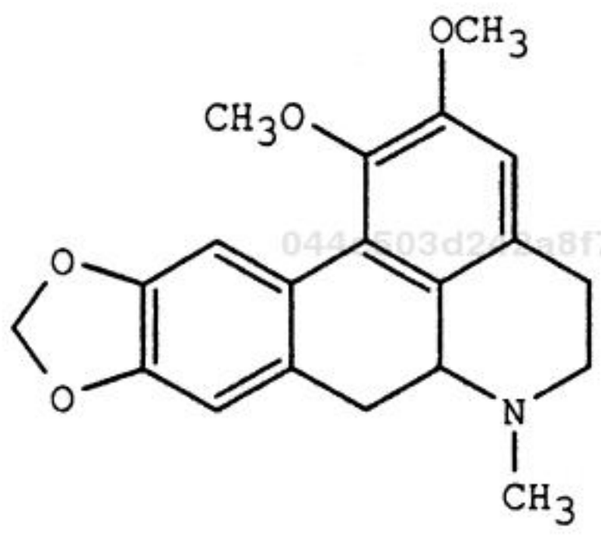

Figure 14.7. Chemical structure of nantenine.

Several protoberberine alkaloids are present in various tissues of *N. domestica*, including berberine, domesticine, dometine, nandinine, and protopine (Manske and Ashford 1954). A serotonin receptor antagonist, nantenine (*O*-methyldomesticine), is also present in the fruits (Shoji et al. 1984). The role of these compounds as toxicants following ingestion of a few berries is not known. For most cultivars, cyanogenesis is the more important intoxication factor.

abrupt onset, apprehension, distress, weakness, ataxia, labored respiration, collapse, seizures, rapid sequence

Clinical Signs—Typical of cyanide intoxication, abrupt onset of apprehension and distress occurs within a few minutes of the animal's browsing the foliage of *Nandina*. This is quickly followed by weakness, ataxia, and labored respiration. If intoxication is severe, the animal may be unable to stand and may lay in lateral recumbency, with periodic paddling and tetanic seizures. The entire sequence of signs may occur in a 5- to 15-minute period, with either death or recovery at the end of this time. Complete recovery may require several hours to overnight.

no lesions
treatment: ruminants, sodium thiosulfate; dogs, sodium nitrite with sodium thiosulfate

Pathology and Treatment—There are few distinctive changes. For the most part, they are limited to congestion of the abdominal viscera and scattered, small splotchy hemorrhages. The primary antidote for ruminants is sodium thiosulfate given i.v. at a dose of 0.25–0.5 g/kg b.w. Sodium nitrite, 10 mg/kg b.w. i.v., can be used to augment the effects of the sodium thiosulfate, but it is not required for effective treatment except in dogs. A more complete discussion is presented in the treatment of the Rosaceae in Chapter 64.

PODOPHYLLUM L.

Taxonomy and Morphology—One of the classic harbingers of spring in the deciduous forests of eastern North America, *Podophyllum* comprises 2–5 species native to both the Old and New World (O'Rourke George 1997). Its name is derived from the Greek roots *podos* and *phyllon*, meaning "foot" and "leaf" alluding to the shape of the leaves (Quattrocchi 2000). Taxonomists differ in their opinions of the taxon's circumscription, some preferring to position the Asian species in separate genera. In North America, 1 species is present:

P. peltatum L. — mayapple, American mandrake, Indian apple, wild lemon, duck's foot, ground lemon, vegetable calomel, podophyllum, podophyllin, devil's apple, vegetable mercury, umbrella leaf

erect herbs; leaves simple, solitary or paired, opposite; petals 6 or 9, white or pink; berries yellow, orange, red or maroon

Plants herbs; rhizomes present, segmented, producing 1 leaf or flowering shoot per year. **Stems** erect; 20–60 cm tall. **Leaves** simple; solitary and basal or paired and cauline; opposite; venation palmate; glossy green; blades reniform orbicular; peltate; margins palmately 5- to 7-lobed or parted; margins of lobes or parts entire or dentate. **Inflorescences** solitary flowers; arising in angle between petioles. **Flowers** fragrant or malodorous; nodding. **Sepals** 6; caducous; white or pale green. **Petals** 6 or 9; white or rarely pink. **Stamens** 6 or 12 or 18. **Berries** ovoid to ellipsoid; yellow or orange or red or maroon. **Seeds** 20–50; yellow or orange or red or maroon (Figures 14.8–14.10).

Figure 14.8. Line drawing of *Podophyllum peltatum*.

Figure 14.9. Photo of the leaves of *Podophyllum peltatum*.

rich, moist woods

Distribution and Habitat—Species of *Podophyllum* occur in the forests of eastern North America and eastern Asia. Adapted to the shaded, rich, moist soils of the forest floors, *P. peltatum* is distributed throughout the eastern half of the continent. One of the first species to begin growth in the spring, it typically forms dense stands and thus is conspicuous in the otherwise leafless woods. Flowering occurs before the canopy closes (Figure 14.11).

roots well-known emetic, used commercially as podophyllin; all plant parts, irritation, digestive disturbance, uncommon