1. INTRODUCTION
Throughout the age’s mankind have relied on nature for their food, clothing, shelter, and medicaments. People have long applied poultices and imbibed infusions of indigenous plants for cures or relief symptom. The oldest record of ethnomedicinal practice dates back to 2600 BC from Mesopotamia describing the use of cedar wood (Cedrus spp.) and chalmugra oil in leprosy, cypress (Cupressus sempervirens), licorice (Glycyrrhiza glabra), myrrh (Commiphora spp.) and poppy (Papaver somniferum) juice for coughs and colds to parasitic infections and inflammation [Newman et al., 2000]. Ethnomedicine is the study of traditional medicines of diverse culture, its knowledge and practices that transmitted orally over the centuries, and evolved over the millennia of human existence. Egyptian ‘Ebers Papyrus’ of 1500 BC documented over 700 medicaments and formulae, while the Chinese Materia Medica (1100 BC) contained formulations described in Shennong and Tang Herbal (659 AD). On the other hand, the Indian Ayurveda (1000 BC) include the classics Atharvaveda (1200 BC), Charak Samhita and Sushrut Samhita (1000-500 BC) describe the use of 857 preparations from 700 herbs [Dev, 1999; Dash and Sharama, 2001]. However, the substantial contribution for the rational development of ethnomedicine was made by the Greek philosopher Theophrastus (~300 BC) who described the medicinal properties of many herbs and their chemical variation in his book ‘History of Plants’, while the Greek physician Galen (130-200 AD) devised the first pharmacopoeia describing the use of hundreds of plants with prescriptions and formulae. However, the foundations of modern pharmaceutical industry come with the idea of ‘pure’ compounds as drugs in early 1800, by the isolation of the active principles strychnine, morphine, atropine and colchicine from plants [Chattopadhyay and Naik, 2007], which initiated the foundation of Natural products chemistry with the work on morphine from opium poppy (Papaver somniferum) by Serturner, and marketed by E. Merck in 1826 [Grabley and Thiericke, 1999]. In the early 1500s, Indian fever bark infusion was used by the native people of the Andes and Amazon highlands to treat fever, but in early 16th century Jesuit missionaries brought these bark to Europe [Patwardhan and Hooper, 1992]. In Andean cultures, the leaves of Erythroxylum coca were chewed for a euphoric sense of happiness and increased energy. Later in 1860, German chemist Carl Koler isolated cocaine from coca, cocaine used as a local anesthetic in surgery and dental
procedures and paralyzed nerve endings responsible for transmitting pain [Grabley and Thiericke, 1999]. Similarly, in 1891 a protein breaking enzyme bromelin was isolated from the pineapple (*Ananas comosus*) juice that breaks down blood clots, from the traditional practice of the American Indians of Guadeloupe Island, who used pineapple poultices to reduce inflammation of wounds and injuries, to aid digestion and cure stomachache. Other pharmaceuticals such as atropine, hyoscine, digoxin, colchicine and emetine also had their origin from ethnomedicinal practice. The anti-hypertensive alkaloid reserpine of *Rauwolfia serpentina* was isolated by Ciba-Geigy in India, while the first semi-synthetic drug aspirin was developed by Bayer in 1899 [Patwardhan and Hooper, 1992; Grabley and Thiericke, 1999]. Thus, the ancient wisdom, the very basis of modern medicine, is an important source today and will remain important for future medicine also. However, the future of ethnomedical drug discovery will be more holistic, and personalized with wise use of ancient and modern therapeutic skills in a complementary manner for maximum benefits [Patwardhan et al., 2008].

### 1.2. THE EVOLVING ROLE OF ETHNOMEDICINE IN DRUG DISCOVERY PROCESS

Earth is estimated to contain about 5,00,000 plant species, 10% of which is used as food and 10-15% as source of drugs [Borris, 1996]. Over the centuries, plant based medicaments of diverse ethnic communities formed the basis of treatment in China [Chang and But, 1986], India [Dev, 1999], Africa, and in many other cultures [Schultes and Raffauf, 1990]. An estimated 80% of the world’s populations rely on plant based medicines for primary health care and 20% use plant products as ingredients of drugs [Farnsworth, 1990].

To date 119 drugs used in modern medicine are derived from 90 plant species, of which 74% are of ethnomedicinal plants. The ethnomedicines of China, India, Tibet and Africa, is ancient but still alive with sound philosophical and experiential basis [Dahanukar and Thatte, 2000; Chopra and Doiphode, 2002], representing medical pluralism with holistic approach and are useful, especially for chronic diseases. Combining the strengths of ethnomedicinal knowledge with the dramatic power of combinatorial sciences and high throughput screening (HTS) scientists can generate structure-activity libraries; while the
experiential database can provide the new functional leads that reduce time, money, toxicity and hurdles in drug development. The development of standardized herbal formulations is undertaken by many countries like India (Golden Triangle approach by the Council of Scientific and Industrial Research, Government of India, 2003), China (Literature Database 1997), Canada (Canadian AIDS Treatment Information Exchange 2005), Brazil (Botsaris 1997), etc. having ethnomedicinal databases [Patwardhan, 2005; Balik, 2006; Sharma et al., 2007]. The Golden Triangle approach has been introduced for the validation of traditional Ayurvedic drugs and development of new drugs.

Globally, in drug discovery and therapeutics, there is a positive trend towards holistic health, integrative sciences, and systems biology approaches. Although the drug discovery process from plants is laborious and time-consuming process but a golden triangle consisting of ethnomedicine, modern medicine and modern science can converge to form a real discovery engine that can result in newer, safer, cheaper and effective therapies (Fig. 1.1).

**Fig. 1.1.** Process of drug discovery from natural source
1.3. PROBLEMS AND PROSPECTS OF ETHNOMEDICINAL DRUG DISCOVERY

The Pharmaceutical research took a major turn as natural products chemists, pharmacologists, microbiologists and biochemists began to unravel the chemistry of ethnomedicines. Many new drugs against infections, cancers, ulcers, heart diseases are resulted from sharp-eyed observations. Studies on new drugs for neglected diseases like malaria, trypanosomiasis, filariasis, tuberculosis, and amoebiasis became almost to a standstill; while there is no suitable drug to stop the emerging and reemerging drug resistant microbes. Pharmaceutical scientists are experiencing difficulties in identifying new lead, templates and scaffolds as the clinical efficacy of many ethnomedicine was not yet evaluated and the composition of many traditional preparations was only crudely analysed [Patwardhan et al. 2008] as well as most synthetic drugs have unacceptable side effects. On the other hand, ethnomedicinal molecules like quinghaosu, artemisinin, rauwolfia alkaloids, psoralens, guggulsterons, mucuna pruriens, piperidines, phyllanthins, curcumine, withanolides, steroidal lactones and glycosides showed impressive successes [Patwardhan, 2005; Sharma et al., 2007].

A major problem with traditional medicine is its reliability and use. In many parts of the world the use of indigenous medicine is broken down, where the indigenous population has been marginalized or limited to small tribal group or a small geographical area. On the other hand, it is difficult to screen vast number of plants for pharmaceutical development, and a considerable time is required to demonstrate true medicinal activities with proven safety profile. As the “great traditions” have relatively organized database with more descriptive material and is easy to test by modern methods, thus, Ayurveda and Chinese Traditional Medicine have an important role in bioprospecting of new medicines [Patwardhan et al., 2004].

1.4. PHYTOCONSTITUENTS AND THEIR BIOLOGICAL ACTIVITIES

1.4.1. Flavonoids

Flavonoids are ubiquitous in photosynthesising cells and therefore occur widely in the plant kingdom [Havsteen, 1983]. They are found in fruit, vegetables, nuts, seeds, stems and flowers as well as tea, wine [Middleton and Chithan, 1986], propolis and honey
[Grange and Davey, 1990], and represent a common constituent of the human diet [Harborne and Baxter, 1999].

The basic structural feature of flavonoid compounds is the 2-phenyl-benzo[α] pyrane, which consists of two benzene rings (A and B), linked through a heterocyclic pyrane ring (C) (Fig. 1.2) [Brown, 1980]. Flavonoids can be classified according to biosynthetic origin. Some classes, for example chalcones, flavanones, flavan-3-ols and flavan-3,4-diols, are both intermediates in biosynthesis as well as end products that can accumulate in plant tissues. Flavones are hydroxylated phenolics containing one carbonyl group instead of two in quinones, while the addition of a third hydroxyl group yields a flavonol. Two additional classes of flavonoid are those in which the 2-phenyl side chain of flavanone isomerises to the 3 position, giving rise to isoflavones and related isoflavonoids. The neoflavonoid is formed through further isomerisation to the 4 position [Harborne and Baxter, 1999].

![Flavone](image1.png) ![Flavan](image2.png) ![Flavonol](image3.png)

**Fig. 1.2**
Fig. 1.3. The skeleton structures of the different classes of flavonoids

1.4.1.1. Pharmacological role of Flavonoids

- **Anti-inflammatory activity**

Inflammation is protective and defense mechanism of the body and The Roman writer Celsus in 1st century AD identified the four Cardinal Signs of inflammation as redness (Rubor), swelling or edema (Tumor), heat (Calor), and pain (Dolor) [Harsh, 2002]. Though inflammation is normally protective but, if untreated, it can go for chronic condition leading to serious complications.

Cyclooxygenase and lipoxygenase play an important role as inflammatory mediators. They are involved in the release of arachidonic acid, which is a starting point for a general inflammatory response. Selected phenolic compounds were shown to inhibit both the cyclooxygenase and 5-lipoxygenase pathways and thus reduce the release of arachidonic acid [Yoshimoto et al., 1983; Ferrandiz and Alcaraz, 1991; Laughton et al., 1991]. The exact mechanism by which flavonoids inhibit these enzymes is not clear.

Quercetin, in particular, inhibits both cyclooxygenase and lipoxygenase activities, thus diminishing the formation of these inflammatory metabolites [Robak and Gryglewski, 1996; Kim et al., 1998]. Another anti-inflammatory feature is the ability of flavonoids to inhibit eicosanoid biosynthesis [Formica and Regelson, 1995; Damas et al., 1985]. Flavonoids also inhibit both cytosolic and membranal tyrosine kinase [Formica and Regelson, 1995]. Another antiinflammatory property of flavonoids is their ability to inhibit neutrophil degranulation. This is a direct way to diminish the release of arachidonic acid by neutrophils and other immune cells [Hoult et al., 1994; Tordera et al., 1994].
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- **Antibacterial and Antifungal activity**

The antibacterial activity of flavonoids is being increasingly documented and crude extracts from plants with a history of use in folk medicine have been screened for in vitro antibacterial activity by many research groups. Flavonoid rich plant extracts from species of *Hypericum* [Dall’Agnol et al., 2003], *Capsella* [El-Abyad et al., 1990] and *Chromolaena* [El-Abyad et al., 1990] have been reported to possess antibacterial activity. Many research groups have isolated different classes of flavonoids that possess antibacterial activity, for examples, flavones [Iniesta-Sanmartin et al., 1990; Zheng et al., 1996; Alcaraz et al., 2000], flavone glycosides [Ng et al., 1996; El-Lakany et al., 1997], isoflavones [Dastidar et al., 2004], flavanones [Tsuchiya et al., 1996; Alcaraz et al., 2000; Deng et al., 2000], isoflavanones [Osawa et al., 1992], isoflavans [Li et al., 1998], flavonols [Nishino et al., 1987], and flavonol glycosides [Ng et al., 1996; Faizi et al., 1999]. Although there have been comparatively few studies into the mechanisms underlying flavonoid antibacterial activity, information from published literature indicates that different compounds within this class of phytochemicals may target different components and functions of the bacterial cell [Haraguchi et al., 1998; Tsuchiya and Iinuma, 2007]. However, it may be that individual antibacterial flavonoids have multiple cellular targets, rather than one specific site of action.

Owing to the widespread ability of flavonoids to inhibit spore germination, they have been proposed to use against fungal pathogens [Harborne and Williams, 2000]. The flavonoid 7-hydroxy-3',4',5'-methylenedioxy flavan, isolated from *Terminalia bellerica* fruit rind, has also been shown to possess activity against *C. albicans* [Valsaraj et al., 1997]. Two new flavones from *Artemisia giraldi*, identified as 6,7,4'-tri hydroxy-3',5'-dimethoxyflavone and 5,5'-dihydroxy-8,2',4'-trimethoxyflavone, together with 5,7,4'- trihydroxy-3',5'-dimethoxyflavone have been reported to exhibit activity against *Aspergillus flavus* [Zheng et al., 1996], a species of fungi that causes invasive disease in immunosuppressed patients [Prescott et al., 1999].

- **Antiviral activity**

Viruses are actually the acellular parasites of cellular host. The virus particles are ultramicroscopic, acellular, metabolically inert nucleoprotein particles containing either
RNA or DNA as genetic material, with or without a lipid envelope [Chattopadhyay et al., 1999]. The genetic variation, variety of transmission, efficient replication and the ability to persist within the host are the major evolutionary advantage of viruses. As a consequence viruses have adapted to all forms of life and have occupied numerous ecological niches resulting in widespread diseases in almost all living organisms [Wagner and Hewlett, 1999; Chattopadhyay and Naik, 2007]. As a metabolically inert particle virus require metabolic pathway of living cells to replicate, which makes it difficult to design a treatment that attack the virion or its replication, without affecting the host [Chattopadhyay et al., 1999]. Although numerous compounds have been tested on different viruses, only 37 licensed antivirals are in the market but the development of antivirals from natural source is less explored, probably because there are very few specific viral targets for small molecules to interact with.

Flavonoid compounds represent an important natural source of antiretroviral agents, especially for AIDS therapy due to their significant anti-HIV-1 activity and low toxicity. Over the past 25 years, since the first case of HIV/AIDS was identified, AIDS has become the largest and most devastating public health pandemic that has infected nearly 70 million people and left 25 million dead [Chattopadhyay and Bhattacharya, 2008]. Flavonoids are well-known inhibitors of many essential enzymes of viral replication, such as viral RTase [Kitamura et al., 1998], Integrase [Kim et al., 1998] and protease [Xu et al., 2000], and form complex with extracellular and soluble proteins.

Wound healing activity

Although traditional medicines offer a safe, inexpensive approach to treatment of wounds, it has not received adequate attention. One of the reasons to neglect this area is that it falls outside WHO’s priority disease areas. Another possible reason is that injuries and chronic wounds tend to be treated locally rather than being presented at clinics under the most advanced stage of pathology [Bodeker, 1995; Bodeker and Hughes, 1998].

There are a number of plants which have been reported for their wound healing activity. Some of these plants either possess pro-wound healing activities or exhibit antimicrobial and other related properties that are beneficial in healing of overall wound care. A number of secondary metabolites or active compounds isolated from
plants have been demonstrated as active principles responsible for facilitating healing of wounds.

Flavonoids are known to reduce lipid peroxidation not only by preventing or slowing the onset of cell necrosis but also by improving vascularity. Hence, any drug that inhibits lipid peroxidation is believed to increase the viability of collagen fibrils by increasing the strength of collagen fibres, increasing the circulation, preventing the cell damage and by promoting the DNA synthesis [Getie et al., 2002]. The high mobility of the electrons in the benzenoid nucleus of flavonoids accounts for both their antioxidant and free-radical scavenging properties, whereas the structural resemblance between the flavonoid aglycone and many substances inherent to the biochemistry of normal biological cells, e.g., nucleic acid bases, coenzymes, steroid hormones, and neurotransmitters, explains their inhibition of enzymes, cytoplasmic/nuclear hormone receptors, and neurotransmitters, as well as gene induction [Havsteen, 2002]. Many studies have shown that antimicrobial activities of plants can also be attributed to their flavonoid content [Owoyele et al., 2008]; hence, they are helpful in prevention of wound infection. Most of the delay in wound healing is due to insufficient or excessive fibroblast activity. Thus, inhibition of fibroblast growth by flavonoids such as apigenin could be beneficial for the treatment of any skin injury. Quercetin may be useful in healing after renal transplantation [Harborne and Williams, 2000].

1.4.2. Terpenoids

Terpenoids produced by plants are of great interest owing to their tremendous variety of structural and functional diversity [Demain and Fang, 2000]. Among the various secondary metabolites, terpenes represent one of the largest and most diverse classes of secondary metabolites [Breitmaier, 2006].

Terpenes exist as five carbon backbones made up of isoprene (2-methylbuta-1,3-diene) units (Fig. 1.4). The functionally modified terpenes are commonly referred to as terpenoids or isoprenoids. Hundreds of different monoterpene (C10), sesquiterpene (C15), diterpene (C20) and triterpene (C30) carbon skeletons are known based on the number of

![Fig. 1.4](attachment:terpenoid.png)
isoprene units [Ashour et al., 2010]. The enormous diversity of structures is responsible for their diverse functional roles [Gershenzon and Dudareva, 2007].

1.4.2.1. Pharmacological role of Terpenoids

- **Anti-inflammatory effects**

Many studies have shown that there is a pool of terpenoids known for their anti-inflammatory properties [Look et al., 1986]. There have been many monoterpenes, such, 1,8-cineole, (-)-linalool and its esters, possess anti-inflammatory activity [Peana et al., 2002]. The anti-inflammatory, pseudopterosins (Fig. 1.5) are diterpene glycosides were originally isolated from the gorgonian coral *Pseudopterogorgia elisabethae* [Roussis et al., 1990] and interestingly anti-inflammatory potential of pseudopterosins is superior to that of standard drugs indomethacin [Look et al., 1986]. Several plant derived triterpenoids, lupane, oleane, ursane, and their natural and synthetic derivatives, have also been identified as anti-inflammatory agents [Recio et al., 1995].

- **Antibacterial and antifungal activity**

Terpenoids have been found to be active against a variety of microorganisms [Miyaoka et al., 1998]. Diterpenes extracted from *Salvia* species have exhibited antibacterial activities against a variety of organisms such as *S. aureus, S. epidermis, E. faecalis, B. subtilis, E. coli,* and *P. mirabilis* [Ulubelen, 2003], similarly, the monoterpenes, menthol, has shown antibacterial activity against *S. aureus* and *E. coli* [Copp, 2003]. The mechanism of antimicrobial action of terpenes is closely associated with their lipophilic character [Hada et al., 2003].

Terpenes also display antifungal activity; one excellent example is the optical isomers of carvone, found to be active toward many kinds of human pathogenic fungi. Carvone and perillaldehyde inhibited the transformation of *Candida albicans* from the coccal to the
filamentous form, which is responsible for the pathogenicity of the fungus [Carvalho and Fonseca, 2006].

- **Wound healing activity**

Terpenoids are known to promote the wound healing process, mainly due to their astringent and antimicrobial properties, which seem to be responsible for wound contraction and an increased rate of epithelialization [Sasidharan *et al*., 2010]. Triterpenes are also responsible for promotion of rapid wound healing [Raina *et al*., 2008]. Sesquiterpene lactones are known to possess antioxidant activity property, which may contribute to the wound healing process [Panda and Tripathy, 2009]. Four terpenoids, asiatic acid, madecassic acid, asiaticoside and madecassoside, isolated from Centella asiatica known to increase collagen synthesis in dose dependent fashion through modulation of gene expression [Colden *et al*., 2003].

- **Antiviral activity**

extract along with purified linalool and ursolic acid showed strong activity against human immunodeficiency virus-1 (HSV-1), Adenovirus 8 (ADV-8), coxsackie B virus type 1 (CVB1) and Enterovirus 71 (EV71). Among these, ursolic acid showed the strongest activity against HSV-1 with an EC$_{50}$ of 6.6 mg/L while linalool showed strongest activity against AVD-II. The antiviral activity of ursolic acid against CVB1 and EV71 is evident during the infection process and the replication phase, indicating that the ursolic acid can be a potential candidate against these RNA viruses [Chiang *et al*., 2005]. The volatile oil 1,8-cineole and terpinen-4-ol of Egyptian plants *Melaleuca armillaris* was more effective virucidal [Farag *et al*., 2004]. Maslinic acid (Fig. 1.6) isolated from *Geum japonicum* can inhibit HIV-1 protease at 17.9 g/ml [Xu *et al*., 1996]. On the other hand, isoborneol (Fig. 1.7), a
monoterpene isolated from *Melaleuca alternifolia* exhibited anti-HSV-1 activity by inactivating HSV-1 replication within 30 min of exposure. At noncytotoxic dose it specifically inhibits glycosylation of viral polypeptides without changes in the glycosylation pattern of cellular polypeptides, indicating isoborneol as an interesting anti-HSV agent [Armaka et al., 1991.]

### 1.5. IDENTIFICATION OF NATURAL PRODUCTS BY CHROMATOGRAPHIC AND SPECTROSCOPIC METHODS

Recently, natural products chemistry has undergone explosive growth due to advances in isolation techniques, synthetic and biosynthetic approaches as well as spectroscopic and chromatographic methods. Modern automated instruments allow characterising very small samples in the nanogram range in a very short time [Harbone, 1973]. The conventional methods of solvent extraction, thin layer chromatography (TLC), column chromatography (CC) yield pure products but nowadays modern methods like: gas-liquid chromatography (GLC); gas-solid chromatography (GSC); thin layer chromatography (TLC); paper chromatography (PC); high performance thin layer chromatography (HPTLC); liquid-solid chromatography (LSC); liquid-liquid chromatography (LLC); bonded phase chromatography (BPC); ion exchange chromatography (IEC); exclusion chromatography (EC); flash chromatography (FC); supercritical fluid chromatography (SFC); high pressure liquid chromatography (HPLC); gel permeation chromatography (GPC); gel filtration chromatography (GFC). Coupling the chromatographic instruments to spectroscopic methods i.e. ultraviolet (UV), nuclear magnetic resonance (NMR), mass spectroscopy (MS), fourier transform infrared (FTIR), Tandem mass spectroscopy (T-MS); enables a partially automated analysis in an even shorter period of time (Fig. 1.8) [Kasture et al., 2007; Sewell and Clarke, 1988].
1.5.1. Structure elucidation

Modern spectroscopic methods have largely revolutionized compound identification and tremendously accelerated the pace at which isolated compounds can be identified nowadays. The structure elucidation of natural products is generally done by combination of elemental analysis and various spectroscopic analyses like infrared (IR), nuclear magnetic resonance (NMR) and mass spectroscopic (MS) techniques [Crews, 1998].

- **Nuclear Magnetic Resonance (NMR) Spectroscopy**

Nuclear magnetic resonance spectroscopy used to elucidate the molecular structures of natural products are based on the application of pulse sequences and magnetic-field gradient pulses that are designed to excite the atomic nuclei of molecules and thereby produce diagnostic signals that can be analysed to determine the connectivity of the $^1$H, $^{13}$C and $^{15}$N nuclei of the molecule. This enables chemists to obtain a very detailed picture of a molecule. In the case of simple small molecules 1-D NMR coupled with MS may be enough to elucidate a compound’s structure. However, most natural products always are not small molecules and simple; in such cases more sophisticated and more powerful 2-D NMR pulse sequences techniques are required. Among the most commonly used 2-D pulse sequences are heteronuclear multiple quantum correlation (HMQC), heteronuclear multiple bond correlation (HMBC), and nuclear Overhauser enhancement spectroscopy (NOESY) [Reynolds and Enriquez, 2002].
Mass Spectroscopy

Although NMR data is probably the most-useful source of information for establishing molecular structure, they need to be complemented by other methods; in particular, no structure should be established without mass-spectral data.

A mass spectrum (MS) has long been used for identifying and quantifying compounds. MS is based on the production of gaseous, positively or negatively charged ions that are subsequently separated according to their mass-to-charge (m/z) ratio and detected [Stroobant and Hoffmann, 2001]. The development of electrospray ionization (ESI) MS has marked a milestone in the analysis of natural products. In contrast to traditional MS techniques such as EI (electron impact), which were applicable only to thermally stable, low molecular weight volatile compounds; virtually any ion (ranging from inorganic salts to large macromolecules such as proteins) can be analyzed by ESI-MS [Stroobant and Hoffmann, 2001]. Another advantage of ESI-MS over other ionization techniques is that it can be directly coupled to high performance liquid chromatography (HPLC). As a result, the interface of HPLC with ESI-MS has provided an excellent method in the identification and isolation of new secondary metabolites from complex extracts [Shipovskov and Reimann, 2007].

IR Spectroscopy

Analytical infrared (IR) spectroscopy covers several aspects that are based on the absorption of electromagnetic radiation with wavelengths in the range of 1 to 1000 µm. This spectral range is typically divided into near-IR (1 to 2.5 µm), mid-IR (2.5 to 25 µm), and far-IR (larger than 25 µm) and mid-IR is the range that is richest in structural information and is the easiest to access. This spectral range is not only used to determine functional groups of a molecule, but it also provides characteristic fingerprint regions that can be used to uniquely identify compounds. It turns out that IR spectroscopy can easily be used as a semiempirical method for structural analysis because it was observed that there is a good correlation between the position of band maxima and organic functional groups or structural characteristics.
CONCLUDING REMARKS

Although today’s drug discovery engine operates at an accelerated pace compared with the era in which natural products were pre-eminent sources of drug leads, numerous approaches have been developed to capture their intrinsic value. Crucial breakthroughs in separation and structure determination technologies have lowered the hurdles inherent in screening mixtures of structurally complex molecules. A greater understanding of the exquisite specificity ingrained in secondary metabolites through the evolutionary process has focused attention on their roles as mediators of protein–protein interactions in vital cellular processes, and advances in synthetic chemistry have revolutionized the processes of material supply and the modulation of biological activity through structural modifications.

Several new drugs derived from natural sources have been launched on the market and these new drugs have been approved for the treatment of infectious diseases, inflammatory and related diseases, wound repairing, cancer, cardiovascular immunological and genetic disorders, which encompass many of the common human diseases. Besides new drugs launched on the market from 2000 to the present, there are a variety of new chemical entities from natural sources undergoing clinical trials. Further research on these compounds at industrial, governmental, and academic institutions is seen as vital for the enhancement of human health.