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Imparts Pharmaceutical Education of International Standards

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Contents

Motto of this Journal
1. To provide scientific, technical and social welfare updates
2. To promote scientific drafting among staff and students
3. To circulate institutional updates
4. To build flat form to serve the community
5. To identify and appreciate potential achievements

Quantum dots for drug delivery and therapy

Mrs Pavani V and Mr Anvesh D

Nanoparticles emerged as a promising tool in drug targeting, since, after appropriate modification, they are able to deliver their payload to specific sites, like tissues, cells, or even certain cellular organelles. Quantum dots (QD's) are one of the nanoparticles that are used in imaging, detection and targeting. They are nanometer-size luminescent semiconductor crystals, which range from 2 to 10 nanometers in diameter (about the width of 50 atoms), whose electronic characteristics are closely related to the size and shape of the individual crystal and have unique chemical and physical properties. Quantum dots have tunable optical properties which can be useful in a wide range of applications from multiplexed analysis such as DNA detection and cell sorting and tracking, to in vivo imaging and diagnostics. Quantum dots are ideal candidates as drug delivery systems because of their outstanding features like a small and uniform size, unique optical properties for most sensitive detection and modifiable surfaces. Newly engineered quantum dots with integrated targeting, imaging and therapeutic functionalities have become excellent material to study drug delivery in cells and small animals. Recent progress in the surface chemistry of quantum dots expanded their use in biological applications, reduced their cytotoxicity and rendered quantum dots a powerful tool for the investigation of distinct cellular processes, like uptake, receptor trafficking and intracellular delivery.

Nanotechnology is the understanding of matter at the nanoscale, at dimensions between approximately 1 and 100 nanometers[1]. Because of their nano-size, nanoparticles have unique physical and chemical properties that give them advantages as drug delivery carriers, or nano-carriers, and diagnosis probes. Owing to fundamental principles of quantum physics nanoscale materials have different properties than the properties of the same materials having larger dimensions[2].

When the dimension of a material is reduced from a large size, the properties remain the same at first, and then small changes occur, until finally when the size drops below 100 nm, dramatic changes in properties can occur. If only one length of a three-dimensional nanostructure is of nanodimension, the structure is referred to as a quantum well; if two sides are of nanometer length, the structure is referred to as a quantum wire. A quantum dot has all three dimensions in the nano range. Materials can be nanostructured for new properties and novel performance[3]. Moreover, at this size range, nanoparticles have a maximum surface:volume ratio, which makes it suitable for surface functionalization along with incorporation of good therapeutics load. Furthermore, due to their nano-size and tunable surface properties (enabling the synthesis of aqueous, injectable solutions and the development of passive or active targeted systems), nanoparticles potentially have better access to target sites as compared to conventional drug delivery carriers.

Over the past few decades quantum dots (QDs) have been an area of intense research due to their unique physical properties. Quantum dots, sometimes called artificial atoms, are tiny nanocrystals made of inorganic transition metal, that glow when stimulated by an external source such as ultraviolet (UV) light. How many atoms are included in the quantum dot determines their size and the size of the quantum dot determines the colour of light emitted. Gallium arsenide (GaAs) is a popular material out of which quantum dots can

be made, other than GaAs they are made up of cadmium selenide (CdSe), cadmium telluride (CdTe), indium phosphide (InP), and indium arsenide They were discovered at the beginning of the 1980s by Alexei Ekimov in a glass matrix and by Louis E. Brus in colloidal solutions. The term "Quantum Dot" was coined by Mark Reed. QDs range from 2-10 nm (10-50 atoms in diameter).

Properties:

1. These nanoparticles have unique optical and electronic properties on account of quantum confinement effect.
2. Fluorescence semiconductor quantum dots have a tunable absorption spectrum, which is very broad, extending from the ultraviolet to a cut-off wavelength in the visible spectrum.
3. quantum dots have brighter emission and good photostability
4. Quantum dots can be molded into different shapes and coated with a variety of biomaterials.
5. Size of the dots controls its emitting colour. e.g. 2nm Quantum dots luminescence bright green,5 nm Quantum dots –luminescence red
6. As size of quantum dots decreases, the wavelength it emits turns shorter.
7. Quantum dots have a broad excitation range.
8. Quantum dots have precise emission wavelength, so the spectra doesn't overlap in multiple fluorescent emission[5].

Preparation:

Fabricating quantum dots with good control over size, material purity, and placement on a given surface is a difficult task. Two approaches are common: the "top-down approach" where a large piece of material is chiseled down to a small quantum dot using the process of lithography and etching. The second approach is "bottom up" and is known as self-assembly. Here, spontaneous congregation of atoms into structures of tunable and uniform size, flexible drug linking and doping mechanisms, large surface to- volume ratio and wide (InAs) as core elements inside a shell, usually zinc sulfide (ZnS)[4].

well defined size (of a few nanometers) and shape form quantum dots.

Uptake of QDs:

QD cellular uptake involves three major stages including endocytosis, sequestration in early endosomes, and translocation to later endosomes or lysosomes. The endocytosis was probably assisted by receptors specific to ligands with negative charges. These findings could be exploited to reduce non-specific targeting, thereby improving specific targeting of QDs in cancer diagnosis and treatment applications. The findings are also important in understanding the cytotoxicity of QDs and other nanomaterials in general and in emphasizing the importance of strict environmental control of nanoparticles [6].

Applications

Quantum dots have properties that provide advantages beneficial for a number of different life science applications. The improved brightness and photostability exhibited by quantum dots are justification for their increased use in imaging and labeling experiments. The ability to render quantum dots biocompatible and non-toxic extends their applicability to *in vivo* vasculature imaging and tracking. The robustness of their signal strength also affords utility in targeting and detection applications. Their simple, routine fabrication protocols and uniform spectral profiles are now allowing quantum dots to realize their full potential, as quantum dot applications are branching out into high throughput, multiplexed analyses and quantitative analysis of biomolecules *in vivo*.

Conclusion

QDs play an important role in fundamental biology and *in vitro* disease diagnostics and prognostics as potent imaging probes. Their unique structural and surface properties, such as their

spectrum of surface reactive groups have enabled a new avenue of research to be opened: targeted and traceable drug

delivery. However, high-quality QDs (visible and near infrared dots with a narrow emission profile and high quantum yield) are mainly made with heavy metals whose long-term toxicity are largely unknown at the current time. Despite this limitation, QDs have been applied to cells and small animals as drug carriers, serving as an outstanding discovery tool for drug screening and validation, and as prototype materials for drug carrier engineering. If high-quality QDs can be prepared from relatively non-toxic compounds (e.g., silicon and carbon), or if the toxic components can be inertly protected from exposure and subsequently cleared from the body, then the clinical relevance of QDs could be anticipated. It seems that future technology will be based entirely on nanotechnology like quantum dots in all sphere of life.

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ROLE OF NANOPARTICLES IN PRODUCTION OF SMART HERBAL DRUGS

Dr. Sneha JA, Ms. Aishwarya Prabha

Nanotechnology is the study, design, creation, synthesis, manipulation, and application of materials, devices, and systems at the nanometer scale (One meter consists of 1 billion nanometers). It is becoming increasingly important in fields like engineering, agriculture, construction, microelectronics and healthcare to mention a few. It is the ability to work at the atomic, molecular and supra molecular levels to create and employ materials, structures, devices and systems with basically new properties. Scientifically, nanotechnology is employed to describe materials, devices and systems with structures and components exhibiting new and significantly improved physical, chemical and biological properties as well as the phenomena and processes enabled by the ability to control properties at nano scale.

NEED FOR DEVELOPMENT OF NOVEL APPROACH FOR PHYTO-PHARMACEUTICALS

Over the last century, phyto-chemical science and phyto-pharmacological science established the numerous botanical products with various biological activities and health promoting benefits. Phytomedicines, complex chemical mixture prepared from plants, have been used in medicine since ancient times and continue to have widespread popular use. Most of the biologically active constituents of plants are polar or water soluble molecules.

The bioavailability of active principles of plants has become an issue of concern for researchers and scholars because of poor oral bioavailability of many plants specifically those containing polyphenolic rings in their structures such as flavonoids and other water soluble constituents like triterpenoids and tannins. Some of the basic reasons for the poor bioavailability of these substances are low water or lipid solubility, high molecular weight/size and poor plasma membrane permeability.

To overcome these problems and to make herbal therapy more effective, these drugs have been incorporated into several novel delivery systems in the recent time. Development of novel drug delivery systems (NDDS) is a new approach for plant extracts and active components. Novel drug delivery system aims to deliver the drug at a rate directed by the needs of the body during the period of treatment, and channel the active entity to the site of action. A number of novel drug delivery systems have emerged encompassing various routes of administration, to achieve controlled and targeted drug delivery. Some of the approaches for bioavailability enhancement formulating at nano scale are polymeric nanoparticles, nanocapsules, liposomes , herbosomes , nanoemulsions, microsphere, transferosomes, and ethosomes.

In recent years, the technique of complexing phytoconstituents or extracts with phospholipids has emerged as a challenging and one of the most successful methods for improving bioavailability and therapeutic efficacy of a number of poorly absorbed plant constituents. Phospholipids based drug delivery systems have been found much hopeful and promising for the effective and efficacious herbal drug deliver and named as phytosomal technology.

APPROACH OF HERBOSOMAL TECHNOLOGY:

It is a patented technology that was introduced and developed by a leading herbal drug manufacturer and nutraceuticals. Herbosome is a synonym of Phytosome. ‘Herbo’ or ‘Phyto’ stands for herbal or plant based and ‘some’

means cell like. Herbosomes, complex of natural active ingredients and phospholipid(s), increase absorption of herbal extracts or isolated active ingredients when applied topically or orally. Herbosomes are cell like structures which result from the stoichiometric reaction of the phospholipids (phosphatidylcholine, phosphatidylserine etc.) with the standardized extract or polyphenolic constituents in a non-polar solvent, which are better absorbed, utilized produce better results than conventional herbal extracts.

This technique incorporates the phospholipids molecules in their structure to form complexes with standardized herbal extracts and/or the specific bioactive ingredient of plant which improves the membrane permeability, water–oil partition coefficient, enhance the systemic bioavailability, enhancement of solubility, ability to cross the cell membranes, protection from toxicity, enhancement of stability, sustained delivery, and protection from physical and chemical degradation of the drugs.

The incorporation of water soluble drugs into their phospholipids complexes has considerably enhanced their bioavailability by increasing penetration through the lipoid plasma membrane while the phospholipids complexation of poorly water soluble drugs had increased their bioavailability by improving their solubility in gastric fluids. The phyto-phospholipid complexation technique in recent years has made it possible to administer high efficacy plant actives with improved biological profile.

IMPORTANCE OF PHOSPHOLIPIDS IN PHYTOSOMAL APPROACH:

Phospholipid molecules has arisen as a potential and unique carrier system for improving the bioavailability of poorly absorbed plant extracts/actives because of their unique structural components, which are similar to the lipid content of the mammalian cell membrane that makes them highly compatible with the human physiological system . It is present in egg yolk, brain tissue and a wide variety of animal fat and plant oils. It is routinely present in the bile fluid, to help emulsify food ingredient for absorption (digestive aid).

Phospholipids molecules are amphipathic having considerable solubility in aqueous and oily mediums. They have a polar and a non-polar portion in their structures. It possesses a cylindrical shape with highest entropy and is involved in formation of bilayer. It contains one saturated and one unsaturated chain in its structure. Phosphatidylethanolamine is cone shaped and doesn't form bilayer itself.

Naturally occurring phospholipids incorporate an unsaturated fatty acid (such as oleic acid, linoleic acid or arachidonic acid) in position 2 and a saturated one (such as stearic acid or palmitic acid) in position. The most commonly used phospholipids (Fig) are those derived from soya bean containing higher proportions that is about 76% of phosphatidylcholine with a high content of polyunsaturated fatty acids like linoleic acid about 70%, linolenic acid and oleic acid.

The soya phospholipids are absorbed at a rate greater than 90% in humans and reach peak plasma concentration in about 6 h after oral administration. The maximum plasma concentration reached was found to be 20% of the dose administered. The phospholipids especially those containing phosphatidylcholine have shown to be incorporated in the cell membrane to replace cellular phospholipids and thus affect the fluidity of the membrane.

The essential or soya phospholipids have shown to be hepatoprotective in nature and prevent liver damage by alcohol, drugs and other toxins. They have also been reported to aid in clearance of serum cholesterol and increase circulating HDL levels in plasma. The presence of proportionally larger amounts of poly-unsaturated fatty acids in soy phospholipids makes it potentially useful in reducing the risk of coronary

heart disease. Essential phospholipids have also shown to possess antilipemic and antiatherogenic effects by impeding the upsurge of total lipids in dietetic hypercholesterolemia in therapeutic as well as prophylactic doses.

APPLICATIONS OF NANOTECHNOLOGY IN HEALTH CARE:

IN PHARMACY:

Traditionally nanotechnology in pharmacy has been associated with drug delivery, where the size of the delivery vehicle, whether it be a liposome, a polymer or even a metallic nano particle and its consequent ability to evade many of our bodies natural defences has been the main attraction. Some of the challenges of most drug delivery systems include poor bioavailability, in vivo stability, solubility, intestinal absorption, sustained and targeted delivery to site of action, therapeutic effectiveness, side effects, and plasma fluctuations of drugs which either fall below the minimum effective concentrations or exceed the safe therapeutic concentrations. However, nanotechnology in drug delivery is an approach designed to overcome these challenges due to the development and fabrication of nanostructures at submicron scale and nanoscale which are mainly polymeric and have multiple advantages.

DISEASE DIAGNOSIS AND PREVENTION:

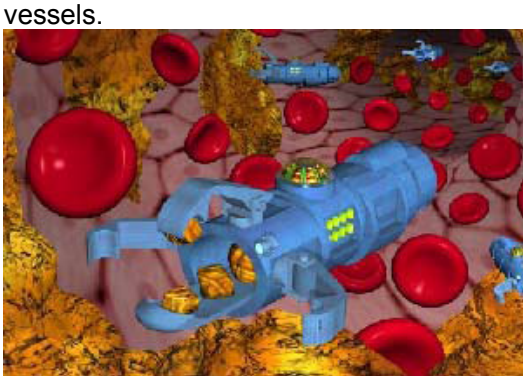
Diagnosis and Imaging-

Nano biotech scientists have successfully produced microchips that are coated with human molecules. The chip is designed to emit an electrical impulse signal when the molecules detect signs of a disease. Special sensor nanobots can be inserted into the blood under the skin where they check blood contents and warn of any possible diseases. They can also be used to monitor the sugar level in the blood. Advantages of using such nanobots are that they are very cheap to produce and easily.

PREVENTING DISEASES:

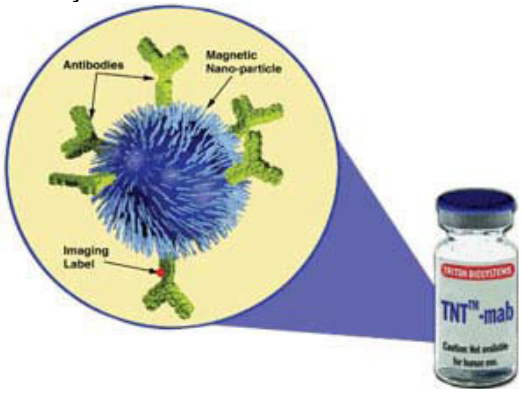
Heart attack prevention-

Nanobots can also be used to prevent heart-attacks. Heart-attacks are caused by fat deposits blocking the blood vessels. Nanobots can be made for removing these fat deposits (Harry, 2005). The following figure shows nanobots removing the yellow fat deposits on the inner side of blood vessels.



Frying tumors-

Nanomaterials have also been investigated into treating cancer. The therapy is based on “cooking tumors” principle. Iron nanoparticles are taken as oral pills and they attach to the tumor. Then a magnetic field is applied and this causes the nanoparticles to heat up and literally cook the tumors from inside.



Cancer Cooker- Triton Bio Systems is developing an anticancer therapy using antibody coated iron nanoparticles

c) Tissue Reconstruction-

Nanoparticles can be designed with a structure very similar to the bone structure.

NANO BIOTECNOLOGY:

Nanotechnology is used in combination with biotechnology to yield development in following areas,

Bio nano-sensors- Combinations of enzymes and silicon chips implanted in humans or animals to monitor health and administer corrective doses of drugs.
Bio mimetic structures- Diagnosis of diseases, molecular imaging and drug delivery

Drug delivery- New formulations for drug and gene therapies
Tissue engineering- Reproduction and repair of damaged tissues using nano material based scaffolds.

ADVANTAGES OF PHYTOSOMES OVER CONVENTIONAL DOSAGE FORMS:
Improved absorption: There is a dramatic enhancement of the bioavailability of plant extracts or bioactive components due to their complexation with phospholipids and improved absorption in the intestinal tract.

Cosmetic use: The formulation of phytosomes is safe and the components have all been approved for pharmaceutical aid and cosmetic use. They can be also used for enhanced permeation of drug through skin for transdermal and dermal delivery. They can be widely used in cosmetics due to their improved skin penetration and have a high lipid profile. Phytosomal formulations can be used as functional cosmetics.

Protective in nature: They have been used to deliver liver-protecting flavonoids because they can be made easily bioavailable by phytosomes. In addition to this, phosphatidylcholine is also hepatoprotective and so provides a synergistic effect for liver protection.

Cost-effective: This technology offers cost-effective delivery of phytoconstituents and synergistic benefits when used as functional cosmetics to protect the skin against exogenous or endogenous hazards in normal as well as stressful environmental conditions.

As a carrier: Phosphatidylcholine, an essential part of the cell membrane used in phytosome technology that acts as a carrier and also nourishes the skin.

Enhance the entrapment efficiency: There is no problem with drug entrapment during formulation preparation. Also, the entrapment efficiency is high and more over-predetermined, because the drug itself forms vesicles after conjugation with lipid.

Improve the stability: They offer a better stability profile because chemical bonds are formed between the phosphatidylcholine molecules and phytoconstituents. The phytosomal system is passive, non-invasive and is suitable for immediate commercialization.

Dose reduction: The dose requirement is reduced due to improved absorption of the main constituent. They can also be given in smaller quantities to achieve the desired results.

Low risk profile: This technology has no large-scale drug development risk since the toxicological profiles of the phytosomal components are well documented in the scientific literature.

Duration of action: Duration of action is increased in case of either sustained or targeted drug delivery system.
Resistance: Phytoconstituents complex with phospholipids are more stable in gastric secretion and resist the action of gut bacteria.

SUMMARY:
Advanced biochemical and preclinical studies have proved the potential of plant flavonoids, polyphenolics and other hydrophilic natural compounds for the treatment of skin disorders, different types of carcinoma, anti aging and many other areas of therapeutics and preventive medicine. There are many phytoconstituents having excellent bioactivity in vitro but less in vivo because of their poor lipid solubility and improper size of the molecule or both, which result in poor absorption and

bioavailability of phytoconstituents through skin and gut and they destroyed in the gastric fluids when taken orally.

Phytosome is a novel approach, a patented technology that was introduced and developed by a leading herbal drug manufacturer and nutraceuticals. In phytosomes, the standardized polyphenolic extract of plant or water soluble phytoconstituents were incorporated into phospholipids to form a lipid compatible molecular complex. This novel approach has improved the absorption and bioavailability of drug. This novel formulation has remarkable advantages over conventional formulations of plant actives and extracts which includes enhancement of solubility, bioavailability, and ability to cross the cell membranes, protection from toxicity, enhancement of stability, sustained delivery, and protection from physical and chemical degradation.

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MECOBALAMIN IN TREATMENT OF SERIOUS NEURODEGENERATIVE DISEASES

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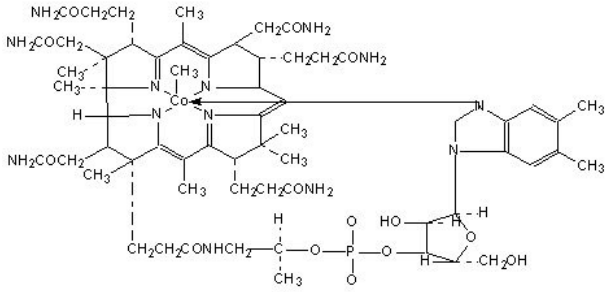
Methylcobalamin (mecobalamin, MeCbl, or MeB12) is a water soluble vitamin. It is a cobalamin, one of the coenzyme forms of vitamin B(12) and acts as an important cofactor in the activities of B(12)-dependent methyltransferases.



Nomenclature: carbanide;cobalt(3+);[5-(5,6-dimethylbenzimidazol-1-yl)-4-hydroxy-2-(hydroxymethyl)oxolan-3-yl] 1-[3-[(4Z,9Z,14Z)-2,13,18-tris(2-amino-2-oxoethyl)-7,12,17-tris(3-amino-3-oxopropyl)-3,5,8,8,13,15,18,19-octamethyl-2,7,12,17-tetrahydro-1H-corrin-21-id-3-yl]propanoylamino]propan-2-yl phosphate

Methylcobalamin is active in growth and protection of the nervous system. Methylcobalamin is equivalent physiologically to vitamin B_{12}, and can be used to prevent or treat pathology arising from a lack of vitamin B_{12} such. Mecobalamin is the most effective neuroprotective agent that is taken up by sub cellular organelles of neuron and can be used through systemic or local led delivery in nervous disorders

MECOBALAMIN AS A NEUROPROTECTIVE AGENT:

Methylcobalamin is usually considered as sport nutrition and exhibits a major role in formation of blood,normal functioning of the brain and nervous system. It is involved in many metabolic processes of DNA synthesis and regulation,fatty acid synthesis and energy production. Vitamin B_{12} is not used directly in human body and thus translated to its active forms such as Mecobalamin or adenosylcobalamin.

Vitamin B_{12}, after conversion into Mecobalamin is involved in:

- Synthesis of methionine and phosphotidylcholine,
- Synthesis of nuclei acid and protein via transmethylation reaction,
- Metabolism of Phospholipids and catecholamines.

In patients with diabetic nephropathy, Mecobalamin stimulates axonal regeneration,repairs injured neuron,antagonises glutamate-induced neurotoxicity improving nerve conduction. It also improves

- Visual function,
- Rheumatoid arthritis,
- Bell's palsy,
- Sleep-wake rhythm disorder,
- Analgesic effects on neuropathic pain

Ultra high doses of Mecobalamin helps in healing of damaged neurons and provide

nutritional support during serious neurodegenerative diseases such as:

- Multiple sclerosis
- Amyotrophic lateral sclerosis
- Parkinson's disease
- Bell's palsy

PHARMACOLOGY:

- Mecobalamin acts as a cofactors for the conversion of homocysteine to methionine that is required for DNA methylation. Methionine synthase involved in the process uses Mecobalamin to transfer the methyl groups from 5-methyltetrahydrofolate.
- It is also involved in the synthesis of phosphotidylcholine, a phospholipid important in the cell membrane structure. Part of phosphotidylcholine becomes choline and is utilised in the synthesis of an important neurotransmitter acetylcholine.
- Mecobalamin also increases the production of erythrocytes in anemia by promoting nuclei acid synthesis in the bone marrow, and maturation that helps in the division of erythrocytes
- Upon oral administration,Mecobalamin is absorbed by the intestine with the use of intrinsic factor and excreted through urine. Urinary excretion of Mecobalamin is low and is reabsorbed which prevents urinary loss and reduces frequency of administration, eventually increasing patient compliance.

SOURCES OF VITAMIN B_{12}:

- The largest amounts of vitamin B_{12} are found in meats, brewer's yeast, eggs,seafood, milk and dairy products. It is not found in many vegetables;it is only available in sea vegetables such as kelp, kombu, and nori. It is also found in soy bean and soy bean products.
- It is believed that bacteria present in large intestine synthesise most of the vitamin $B_{12.}$

LABORATORY PREPARATION:

- Methylcobalamin can be produced in the laboratory by reducing cyanocobalamin with sodium borohydride in alkaline solution, followed by the addition of methyl iodide. It can be obtained as bright red crystals.

DOSAGE FORMS AVAILABLE:

Oral: For peripheral neuropathies:

Dose-Adult: 1500 mcg/day in 3 divided doses.

Parenteral: For peripheral neuropathies:

Dose-Adult: 500 mcg daily IM/IV, 3 times/week.

MARKETED PREPARATIONS:

Oral Marketed preparations include:

- COBALVIT-OD(Intra labs)-1.5 mg
- AXINEURON-OD (Medihealth)-1500 mcg
- NURODAY (Wockhardt)-1500 mcg
- MEDINERV (Procure)-1500 mcg etc..

Parenteral Marketed preparations include:

- NEUTRON (Icarus)-1000 mcg
- COBANERVE (Invision)-500mcg/ml,1 ml
- E-COB (Zota)-500 mcg,1 ml
- MEBEL (Neesee) -1500 mcg,2 ml etc..

THERAPEUTIC USES:

- Neuropathy
- Male infertility
- Paralysis
- Low back pain
- Parkinson's disease
- Neuralgia
- Dementia
- Amyotrophic lateral sclerosis
- Traumatic Nerve Injury
- Sciatica Pain
- Bell's Palsy
- Multiple sclerosis
- Vertigo

INTERACTIONS:

- Decreased GI tract absorption withNeomycin, Aminosalicylic acid, H_2-blockers and Colchicine,
- Reduced serum concentrations with oral contraceptives,
- Reduced effects in anaemia with parenteral Chloramphenicol.

ADVERSE EFFECTS:

Oral: Anorexia,nausea,vomiting and diarrhoea.

Parenteral: Rash, head ache, hot sensation, diaphoresis and pain/induration at IM injection site. Anaphylactoid reactions.

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Human Excellence Centre Programs:

The Human excellence Centre of GRCP conducted one day motivational program for the benefit of staff and students on 08th March 2014. Prof V. Viswanatham, Vivekananda Institute of Human Excellence, Ramakrishna Mutt, Hyd. elaborated on the title Becoming a better student and Dr Vivek Modi, Vivekananda Institute of Human Excellence, Ramakrishna Mutt, Hyd, delivered a lecture on Success Manthra.

PharmTech-FEST-2014

A Technical Fest, titled "PharmTechFest-2014" was organized by GRCP on 8th March 2014 for under AICTE sponsored Institute Industry Partnership Cell (IIPC). The PharmTech Fest-2014 permitted the students of Pharmacy colleges around the country to exchange their knowledge and ideas. Dr. Ramesh Panchangnula, Vice-President, Nectar Therapeutics, Hyderabad, inaugurated the function. Sri J. Rajamouli, Managing Director, SunRise International Labs, Hyderabad, was guest of honour for valedictory function. Dr. M. Kiran Kumar, Vice-president, Appcure Labs, Hyderabad, Dr. K. Venugopal, Manager, Analytical R&D, Mylan Labs, Hyderabad, and Dr. B. Ramakrishna, Senior Vice-President, Mylan Labs, Hyderabad were the other resource persons of the PharmTech-2014.