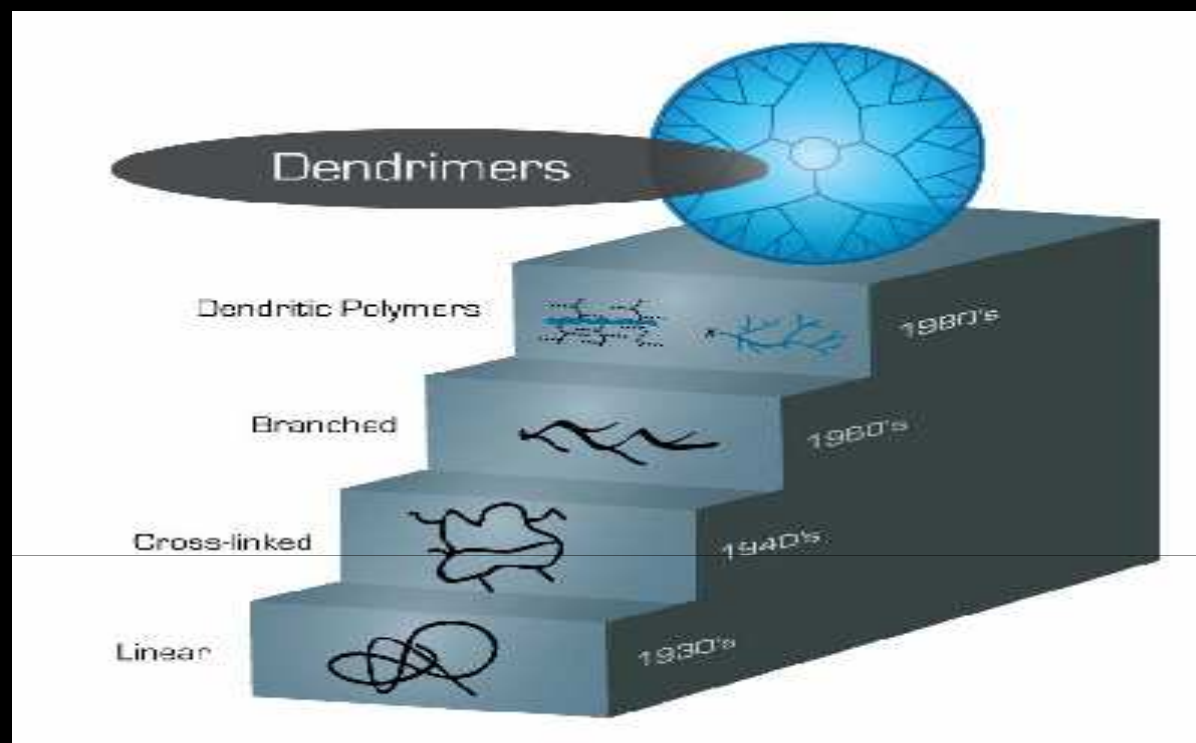


POLYMERS OF THE 21st CENTURY

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Introduction



Dendrimers are synthetic macromolecules with a tree-like well-defined branched structure.

The word "*dendrimer*" originated from two words, the Greek word *dendron*, meaning tree, and *meros*, meaning part.

Structure

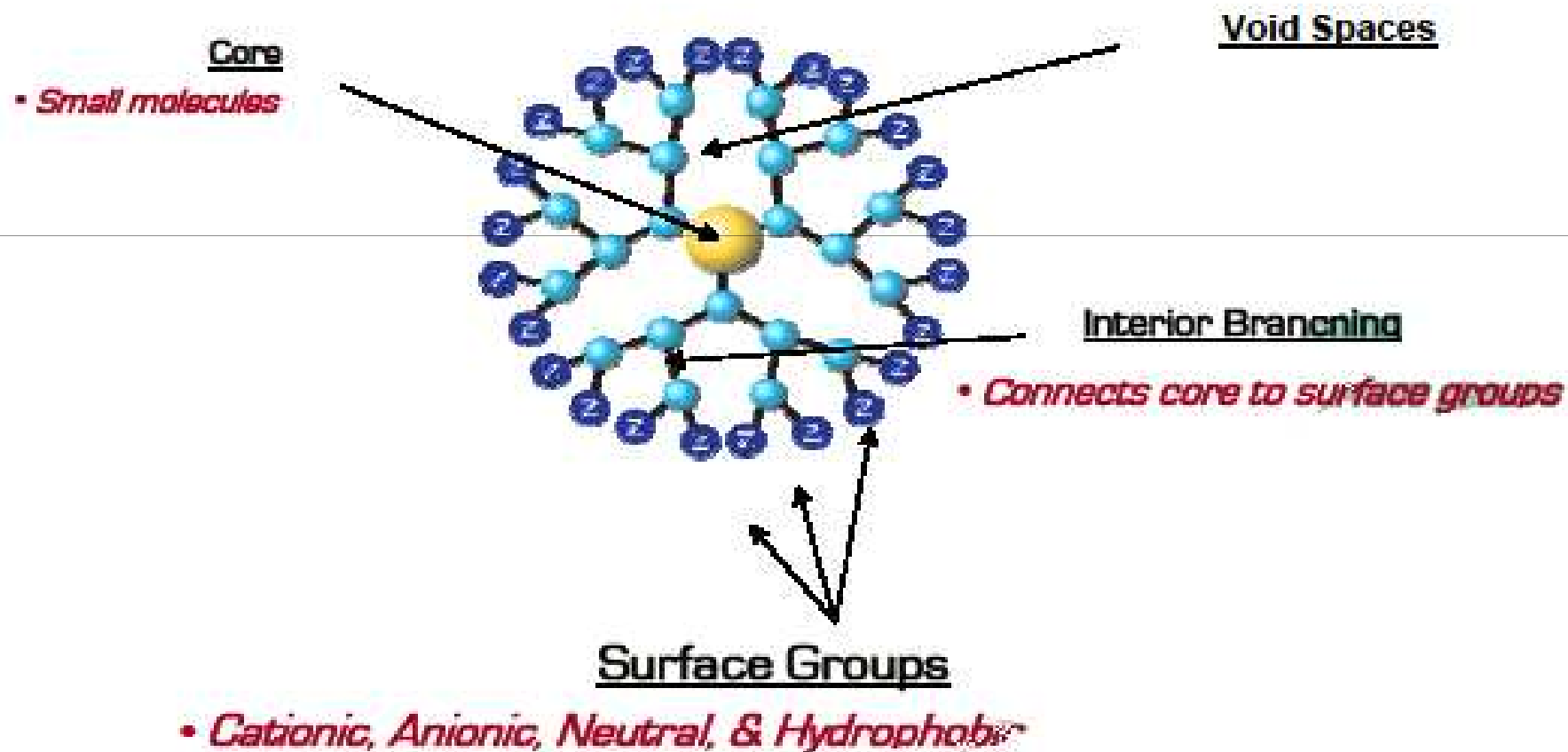
Dendrimers possess three distinguished architectural components , namely

(i) An initiator core

(ii) Interior layers (generations) composed of repeating units, radically attached to the interior core



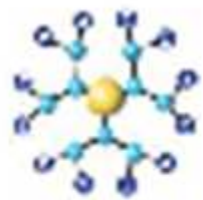
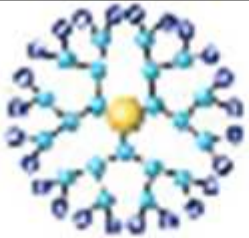
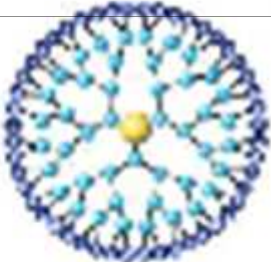





(iii) Exterior (terminal functionality) attached to the outermost interior generations.

General Structure of Dendrimers



Dendrimers diameter increase linearly per generations, whereas the number of surface groups increasingly geometrical

Dendrimers of lower generations (0, 1, and 2) have highly asymmetric shape and possess more open structures as compared to higher generation dendrimers.

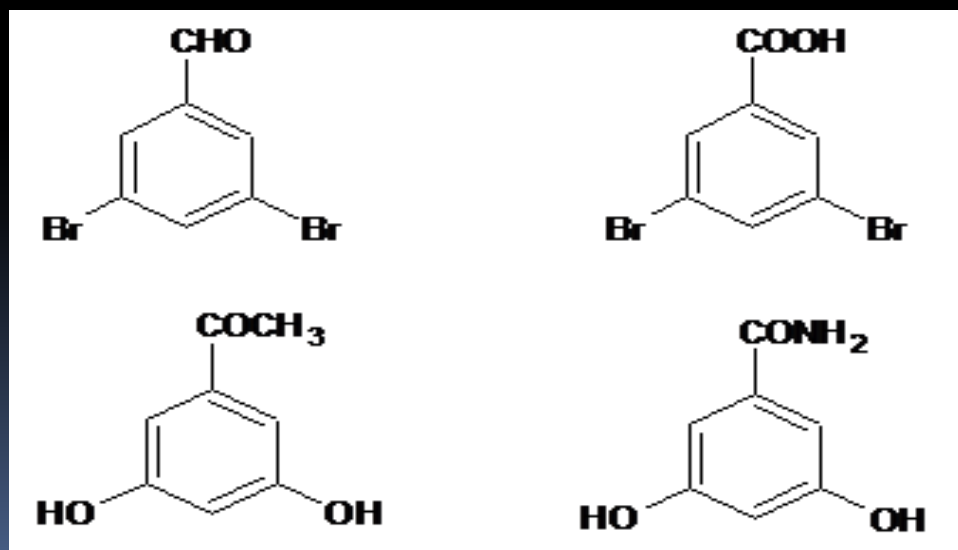
Generation	G0	G1	G2	G3	G4
# of Surface Groups	3	6	12	24	48
Diameter (nm)	1.4	1.9	2.6	3.6	4.4
3D Graphical Representation					
3D Chemical Structure					

Synthesis

Many dendrimer syntheses rely upon traditional reactions, such as the Michael reaction, solid-phase synthesis

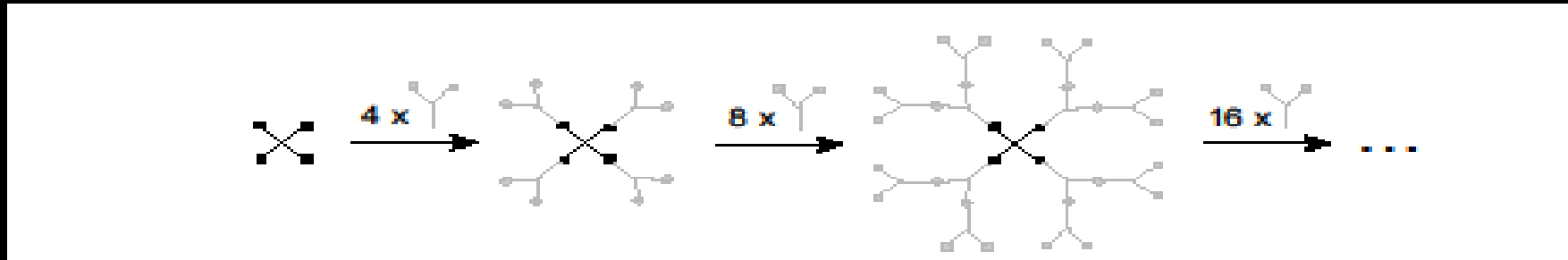
Branching may either be present in the building blocks or as it can be created as a function of the growth reaction.

Trisubstituted benzene can be used as building blocks

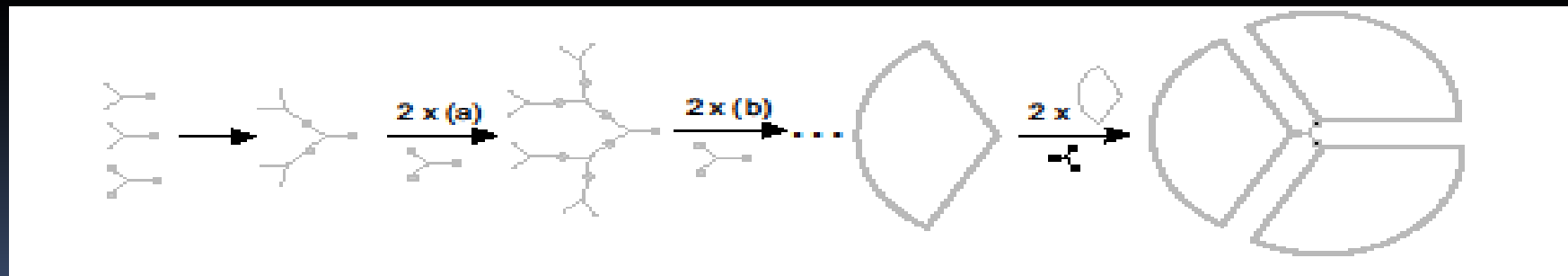


Dendrimers are generally prepared using either a divergent method or a convergent method

In the divergent methods, dendrimer grows outwards from a multifunctional core molecule.

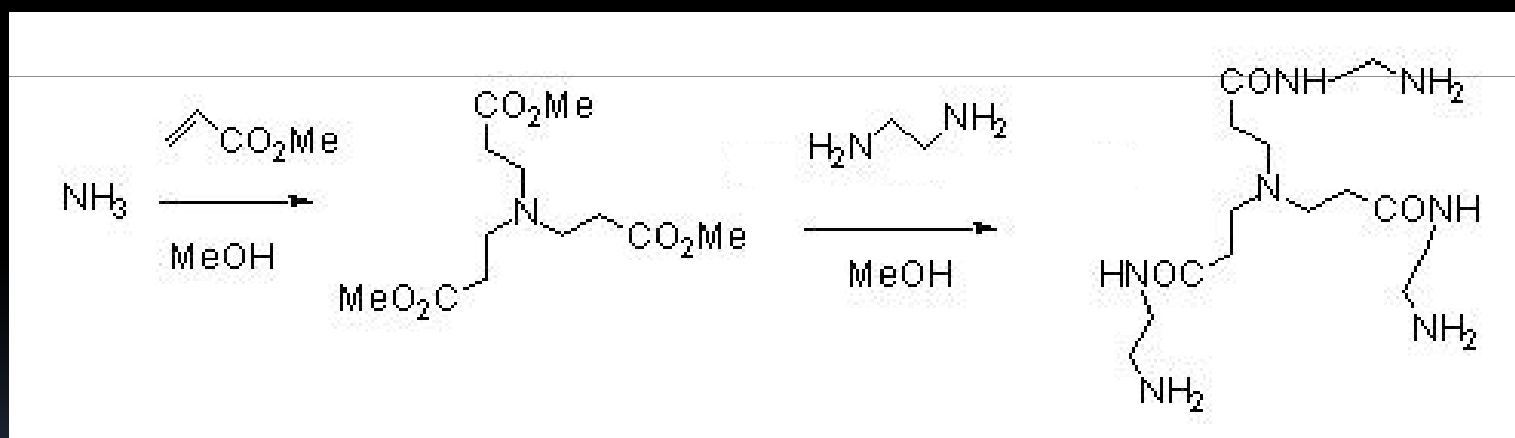


In the convergent approach, the dendrimer is constructed stepwise, starting from the end groups and progressing inwards.



These two methods both suffer from major problems, the necessity for repeated and time-consuming purifications.

The first synthesised dendrimers were polyamidoamines (**PAMAMs**) They are also known as starburst dendrimers. PAMAM (polyamidoamine) dendrimers were first synthesised by Tomalia et al. The general synthesis is a two-step process involving exhaustive Michael addition of a suitable amine initiator core with methyl acrylate and exhaustive amidation of the resulting esters with large excesses of 1,2-alkanediamines. In this way, dendrimers up to the ninth generation were produced

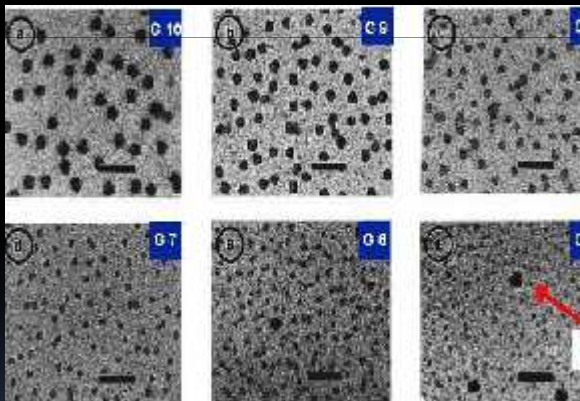


At the end of each branch there is a free amino group that can react with two methyl acrylate monomers and two ethylenediamine molecules. Each complete reaction sequence results in a new dendrimer generation.

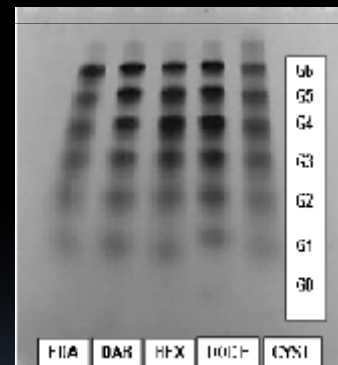
Characterization of Dendritic Polymer

Different methods can be used for characterization of dendritic polymers.

Spectroscopy methods ,Scattering techniques ,Electrical techniques, Size exclusion chromatography, Transmission electron microscopy, Scanning electron microscopy, Rheology, physical properties like intrinsic viscosity, Differential Scanning Calorimetry (DSC) .



Visualization of Dendrimers by TEM



Electrophoresis of Dendrimers with Various Cores (Generation 0-6)

Properties of Dendrimer and linear polymers

Property	Dendrimers	Linear Polymers
Structure	Compact, Globular	Not compact
Synthesis	stepwise growth	Single step polycondensation
Structural control	Very high	Low
Architecture	Regular	Irregular
Shape	Spherical	Random coil
Crystallinity	Non-crystalline, amorphous materials	Semi crystalline/crystalline materials
Aqueous solubility	High	Low
Nonpolar solubility	High	Low
Viscosity	Non linear relationship with molecular weight	Linear relation with molecular weight
Reactivity	High	Low
Compressibility	Low	High
Polydispersity	Monodisperse	Polydisperse

Biological properties

- ✓“Cationic” dendrimers are generally haemolytic and cytotoxic.
- ✓Their toxicity is generation-dependent and increases with the number of surface groups
- ✓PAMAM dendrimers (generation 2, 3 and 4) interact with erythrocyte membrane proteins causing changes in protein conformation.
- ✓Anionic dendrimers, bearing a carboxylate surface, are not cytotoxic over a broad concentration range [20].

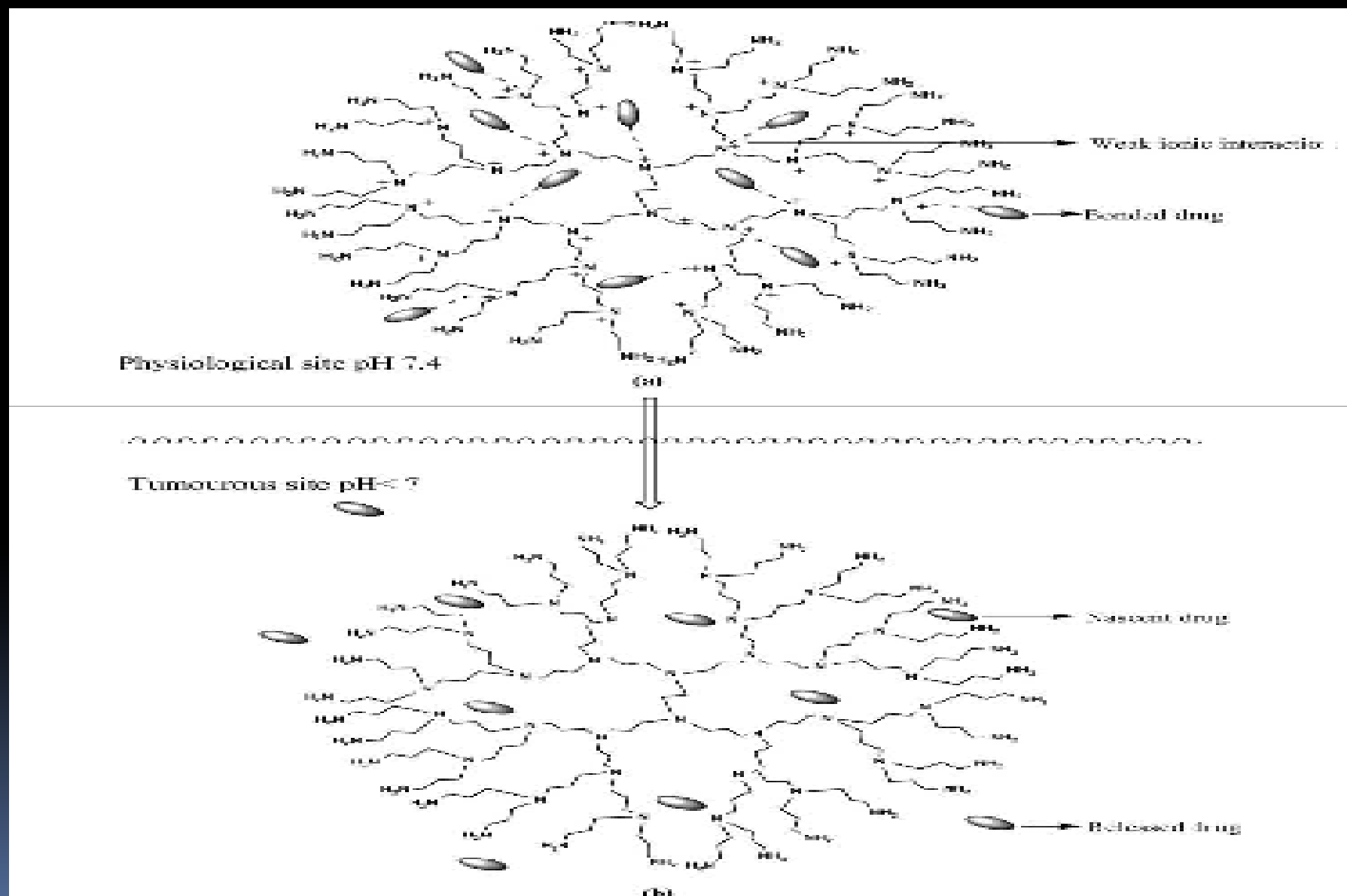
Applications

Many applications of dendrimers are based on their molecular uniformity, multifunctional surface and presence of internal cavities.

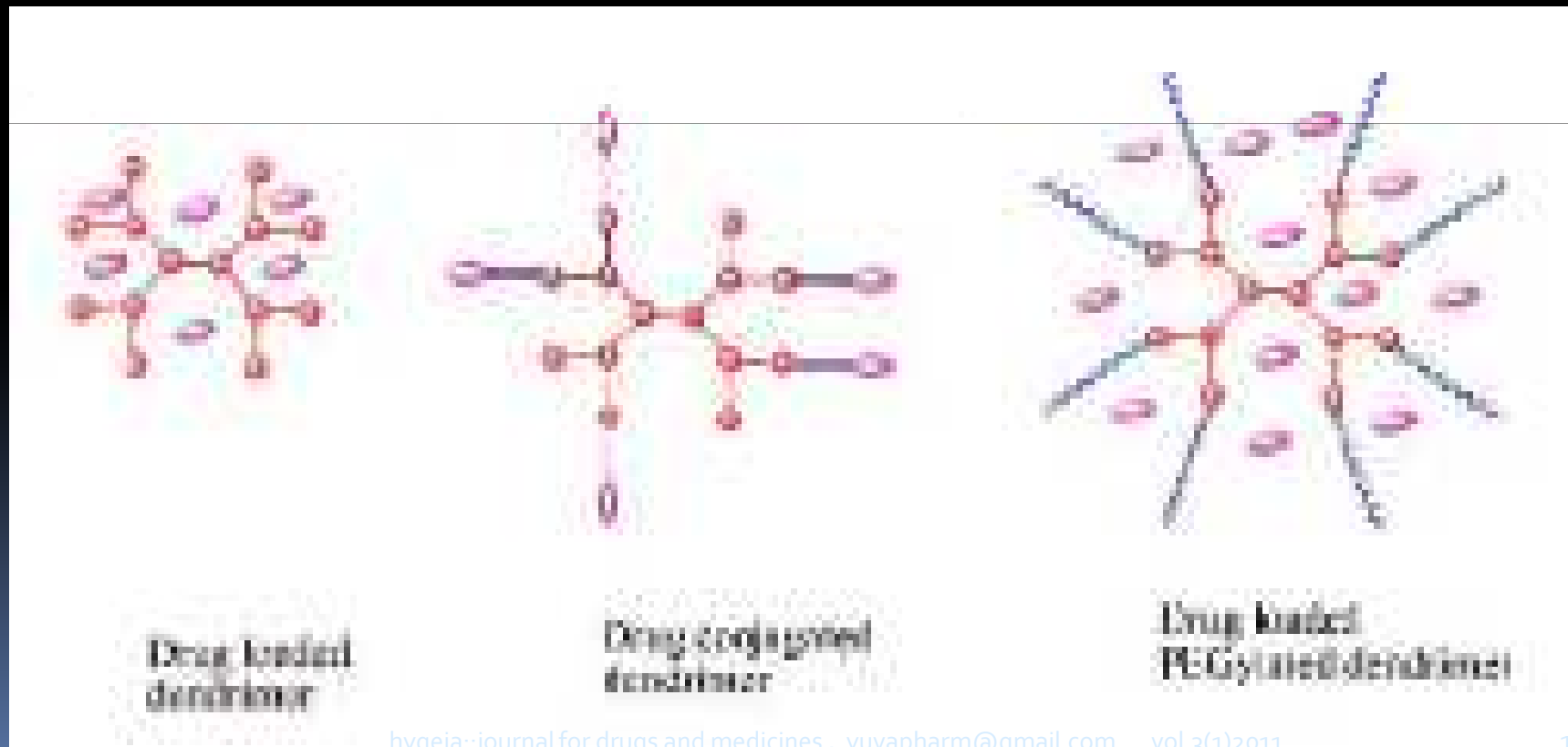
Pharmaceutical Application

Dendrimers as possible drug carriers : Drug molecules can be loaded both in the interior of the dendrimers as well as attached to the surface groups. Dendrimers can function as drug carriers either by encapsulating drugs within the dendritic structure, or by inter-acting with drugs at their terminal functional groups via electrostatic or covalent bonds (prodrug).

Mechanism of drug release following deprotonation from drug encapsulated dendrimers at tumorous site.



- Drug Conjugated Dendrimers in Cancer therapy reducing the toxicity
- PEGylated Nanocarriers in Cancer Therapy. The increase in the water-solubility of paclitaxel by PGDs



- PAMAM dendrimers are a class of polycationic synthetic polymers that can be used for gene transfer.
- Dendrimers have been tested in preclinical studies as **contrast agents for magnetic resonance.**

Non Pharmaceutical application

- The combination of high surface area and high solubility makes dendrimers useful as nanoscale catalysts

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