BIOMATERIAL
Biopolymer

Nur Istianah, ST.,MT.,M.Eng

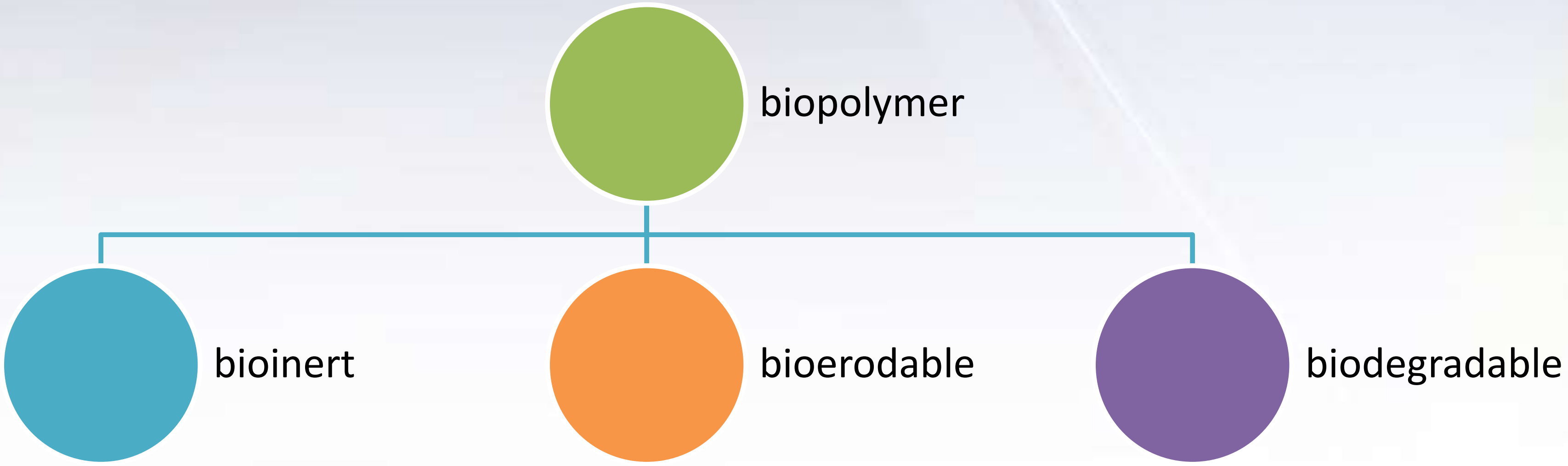
Polymer

synthesized from monomer

Biopolymers – biobased polymer

Bio-synthetic polymers: plastic	natural polymers: proteins, polysaccharides

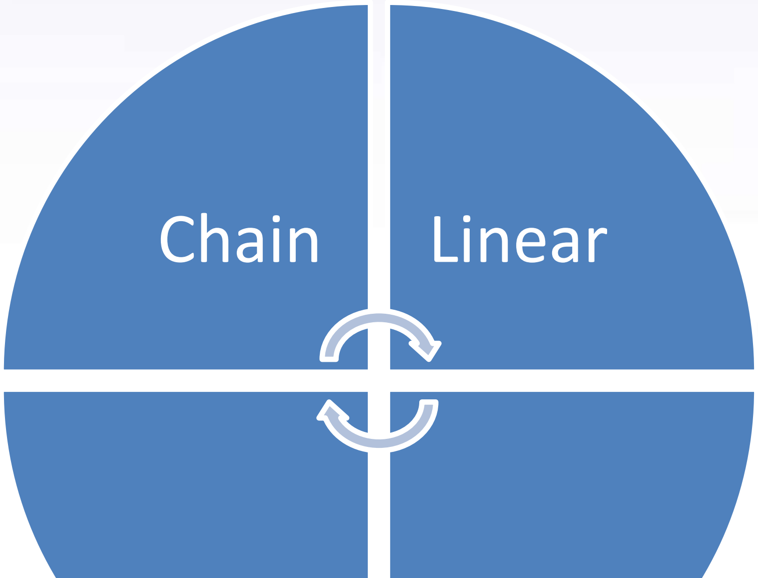
Biopolymer



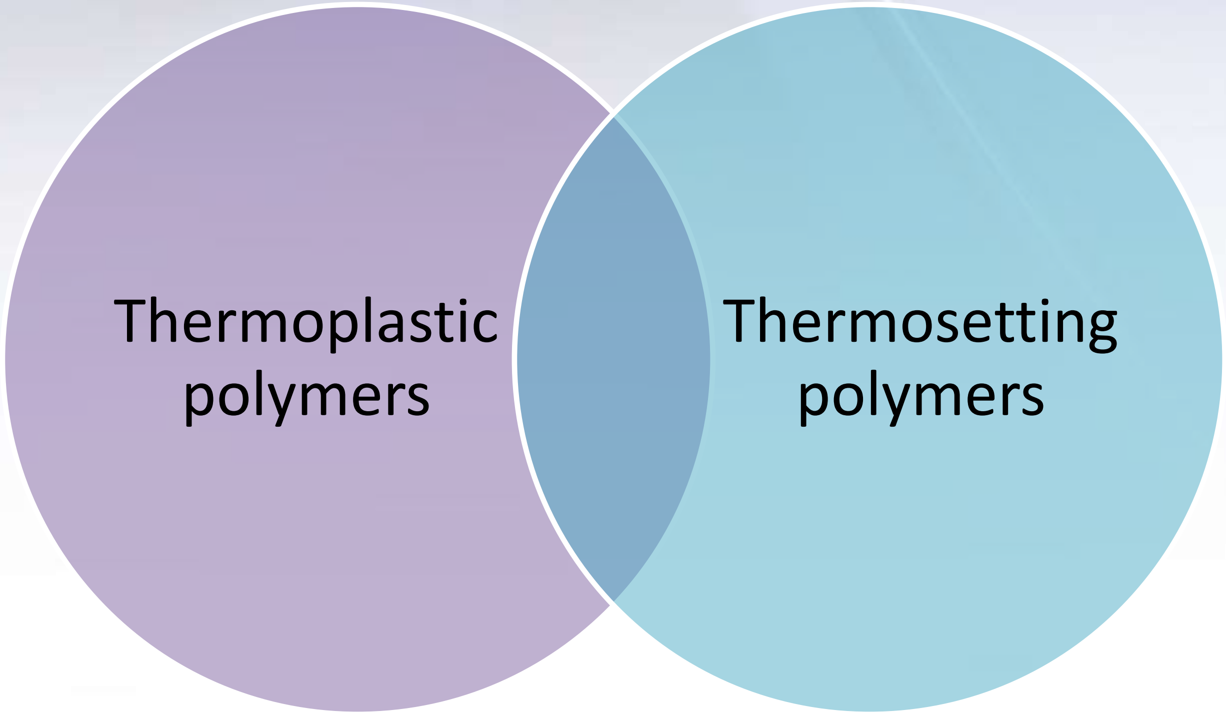
- Bioinert polymers are nontoxic in vivo and do not degrade significantly even over many years.
- Polymers can degrade by simple chemical means or under the action of enzymes.
- Bioerodable polymers such as polylactide are those that degrade by simple chemical means, and biodegradable polymers are those that degrade with the help of enzymes.
- Most natural polymers (proteins, polysaccharides, and polynucleotides) are biodegradable, whereas most synthetic degradable polymers are bioerodable.
- The most common degradation reactions for bioerodable polymers are hydrolysis and oxidation.

Bipolymer syntesis

- Polymers are frequently classified by their synthesis mechanism as either step or chain polymers.
- Step polymers are formed by step wise reactions between functional groups.



Bipolymer syntesis



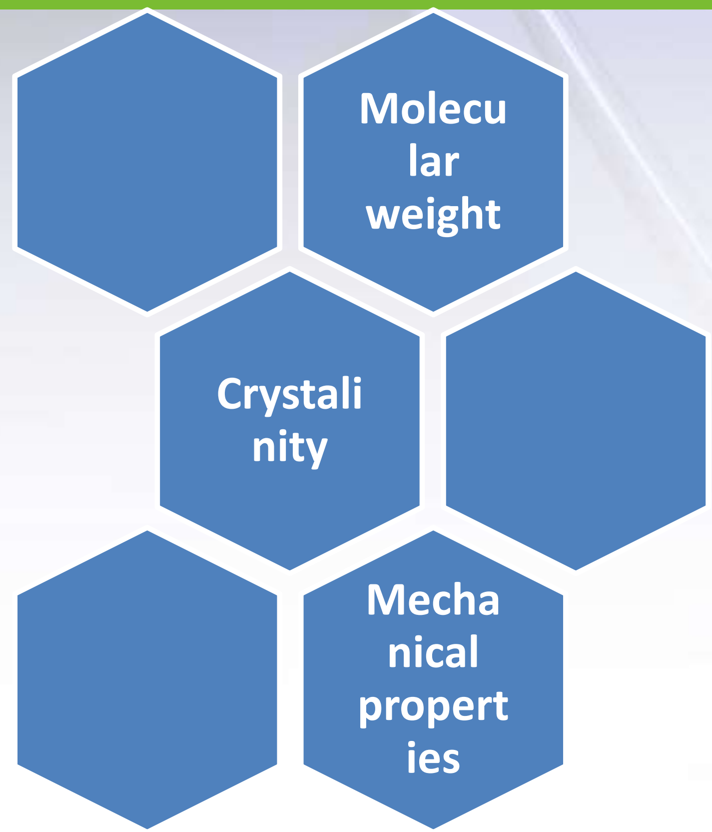
Thermoplastic polymers

- Thermoplastic polymers are made of individual polymer chains that are held together by relatively weak van der Waals and dipole-dipole forces. Thermoplastic polymers can be processed into useful products by melt processing, namely, injection molding and extrusion. They can also be dissolved in solvents and cast to form films and other devices.
- Although they often degrade or denature before melting, most proteins and polysaccharides can be considered thermoplastics since they are made of individual chains and can be dissolved in solvents.
- Finally, thermoplastics can be linear or branched.

Thermosetting polymers

- Thermosetting polymers contain cross-links between polymer chains. Cross-links are covalent bonds between chains and can be formed using monomers with functionalities of greater than 2 during synthesis.
- Some polyurethanes and many silicones are formed using monomers with functionalities greater than 2. Cross-links also can be created after the polymer is formed

Biopolymer properties



Molecular weight

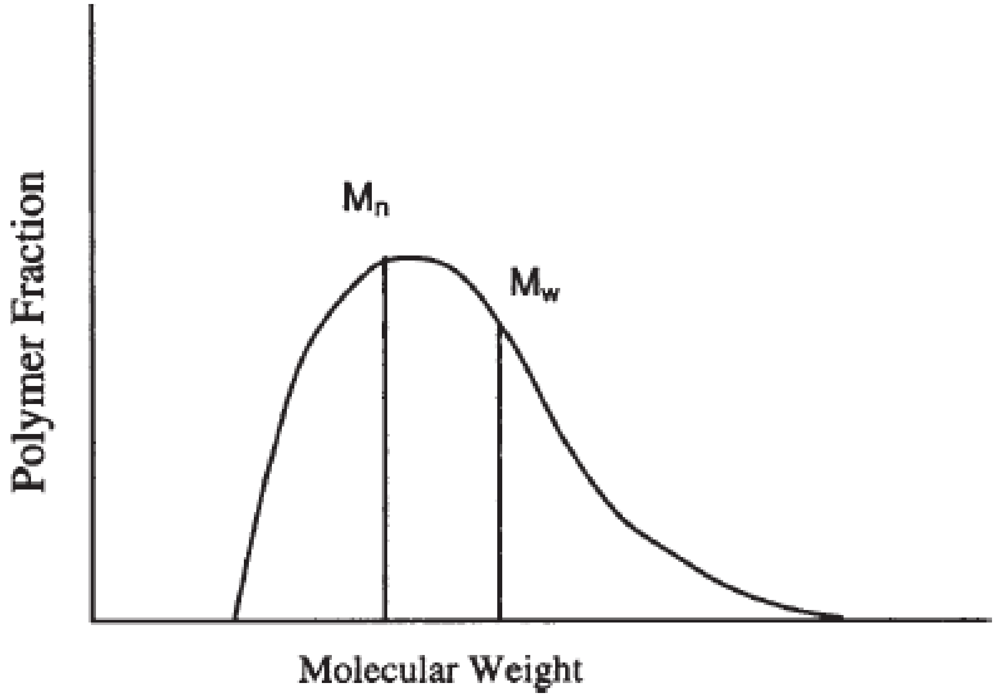


FIGURE 11.1 Typical polymer molecular weight distribution.

$$M_n = \frac{\Sigma N_i M_i}{\Sigma N_i}$$

$$M_w = \frac{\Sigma N_i M_i^2}{\Sigma N_i M_i}$$

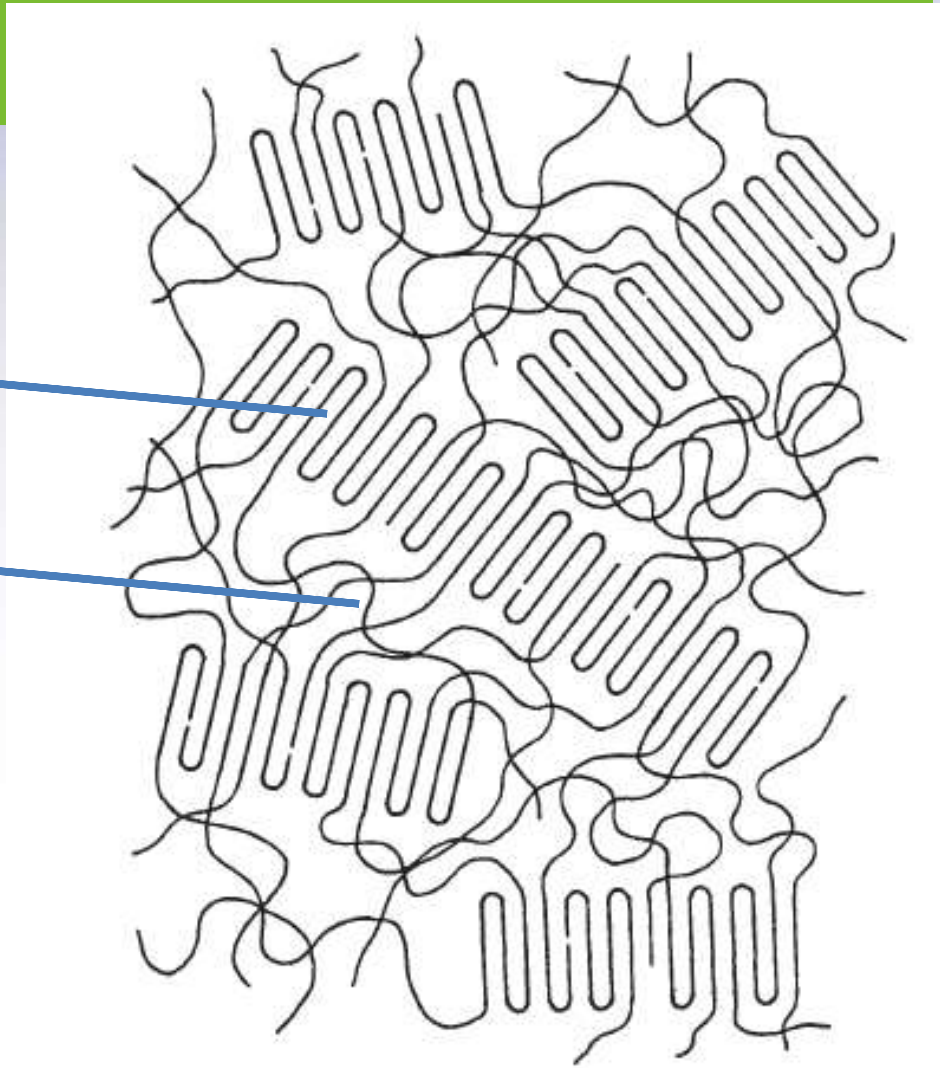
Crystalinity

- Polymers in the solid state have varying degrees of crystallinity. No polymer is truly 100 percent crystalline, but some are purely amorphous.
- Modulus strength increase with crystallinity. Ductility decreases with crystallinity since polymer chains have less room to slide past each other.
- The primary requirement for crystallinity is an ordered repeating chain structure.

Crystalinity

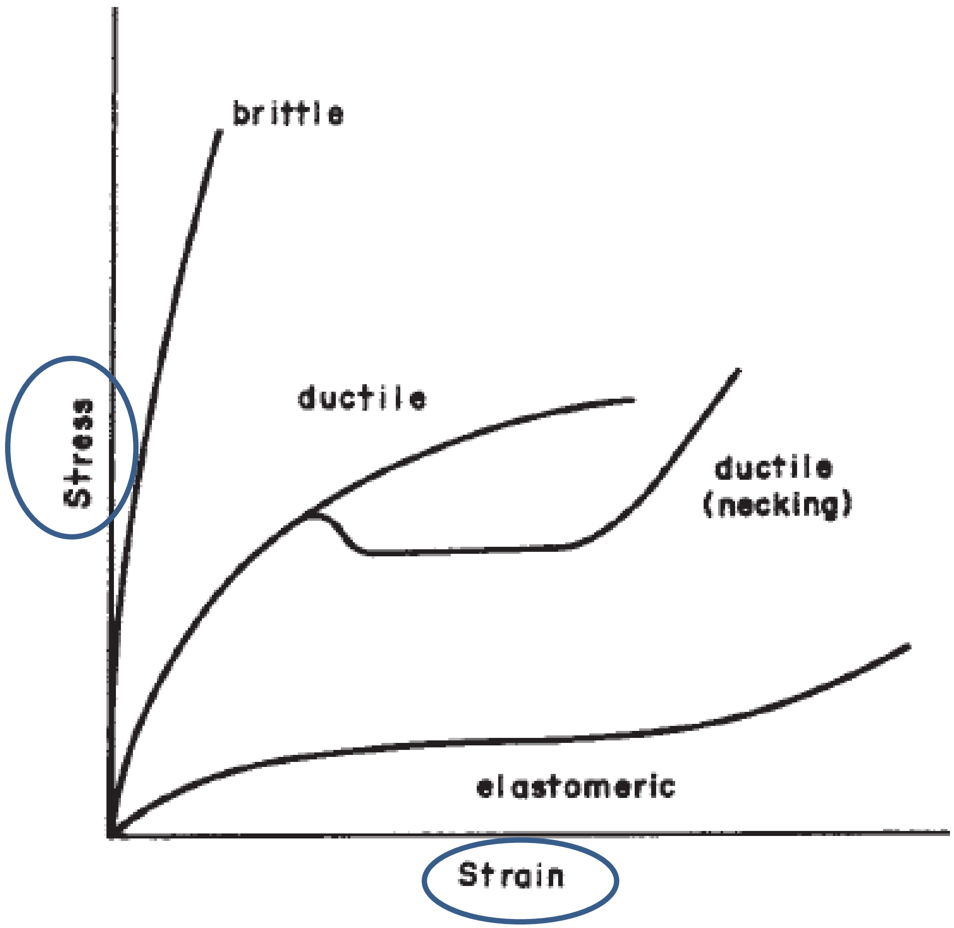
Crystaline

Amorf



Mechanical properties

- Solid polymer mechanical properties can be classified into three categories: brittle, ductile, and elastomeric



Mechanical properties

- Brittle polymers are polymers with a *Tg* that is much higher than room temperature, such as PMMA. These polymers have a high modulus and high ultimate tensile strength but low ductility.
- Ductile polymers are semicrystalline polymers such as polyethylene and PTFE that have a *Tg* below room temperature for the amorphous polymer content. These polymers have lower strength and modulus but greater toughness than brittle polymers.
- Elastomers have low moduli since they have a *Tg* well below room temperature, but they can return to their original shape following high extensions since cross-links prevent significant polymer chain translations.

Mechanical properties

- Polymers can exhibit both viscous and solid mechanical behavior; this phenomenon is called *viscoelasticity.* For a given polymer, the degree of viscous behavior depends on temperature.
- Below *Tg*, polymers will behave more or less as elastic solids with very little viscous behavior.
- Above *Tg*, polymers exhibit viscoelastic behavior until they reach their melting temperature, where they behave as liquids.

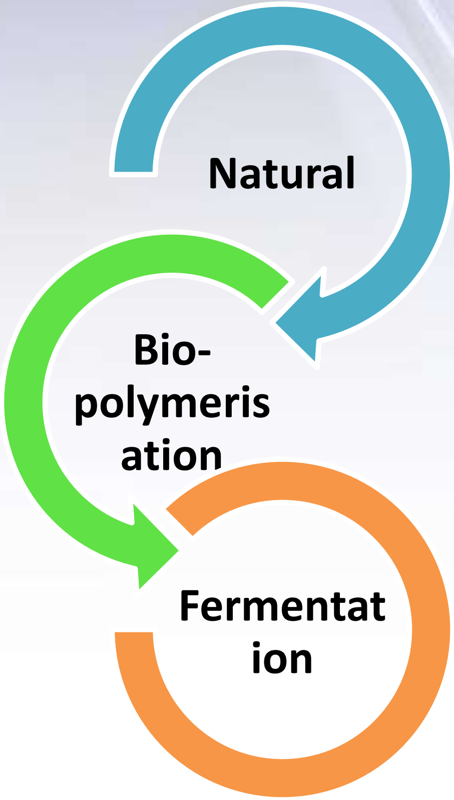
Bio-based polymer

- Biobased polymers are materials which are produced from renewable resources
- Biobased polymers can be biodegradable (e.g., polylactic acid) or nondegradable (e.g., biopolyhethylene).
- Similarly, while many biobased polymers are biodegradable (e.g., starch and polyhydroxyalkanoates), not all biodegradable polymers are biobased (e.g., polycaprolactone).
- Biobased polymers offer important contributions by reducing the dependence on fossil fuels and through the related positive environmental impacts such as reduced carbon dioxide emissions.

Bio-based polymer

- The first generation of biobased polymers focused on deriving polymers from agricultural feedstocks such as corn, potatoes, and other carbohydrate feedstocks
- Biobased polymers similar to conventional polymers are produced by bacterial fermentation processes by synthesizing the building blocks (monomers) from renewable resources, including lignocellulosic biomass (starch and cellulose), fatty acids, and organic waste.
- Natural biobased polymers are the other class of biobased polymers which are found naturally, such as proteins, nucleic acids, and polysaccharides (collagen, chitosan, etc.).

Bio-based polymer production



- (1) Using natural biobased polymers with partial modification to meet the requirements (e.g., starch)
- (2) Producing biobased monomers by fermentation/conventional chemistry followed by polymerization (e.g., polylactic acid, polybutylene succinate, and polyethylene)
- (3) Producing biobased polymers directly by bacteria (e.g., polyhydroxyalkanoates).

- PLA can be synthesized from lactic acid by direct polycondensation reaction or ringopening polymerization of lactide monomer.
- Polyhydroxyalkanoates (PHAs) are a family of polyesters produced by bacterial fermentation with the potential to replace conventional hydrocarbonbased polymers
- Bio Polyethylene (PE) is an important engineering polymer traditionally produced from fossil resources. PE is produced by polymerization of ethylene under pressure, temperature, in the presence of a catalyst.

Bio-PE

- bioPE produced on an industrial scale from bioethanol is derived from sugarcane. Bioethanol is also derived from biorenewable feedstocks, including sugar beet, starch crops such as maize, wood, wheat, corn, and other plant wastes through microbial strain and biological fermentation process. In a typical process, extracted sugarcane juice with high sucrose content is anaerobically fermented to produce ethanol. At the end of the fermentation process, ethanol is distilled in order to remove water and to yield azeotropic mixture of hydrous ethanol. Ethanol is then dehydrated at high temperatures over a solid catalyst to produce ethylene and, subsequently, polyethylene

Bio-PE

- Biobased polyethylene has exactly the same chemical, physical, and mechanical properties as petrochemical polyethylene.
- The current Braskem biobased PE grades are mainly targeted towards food packing, cosmetics, personal care, automotive parts, and toys.
- BioPE can replace all the applications of current fossilbased PE. It is widely used in engineering, agriculture, packaging, and many daytoday commodity applications because of its low price and good performance

Biobased polymers are closer to the reality of replacing conventional polymers than ever before. Nowadays, biobased polymers are commonly found in many applications from commodity to hitech applications due to advancement in biotechnologies and public awareness.

THANKS FOR YOUR ATTENTION

The best person is one give something useful always