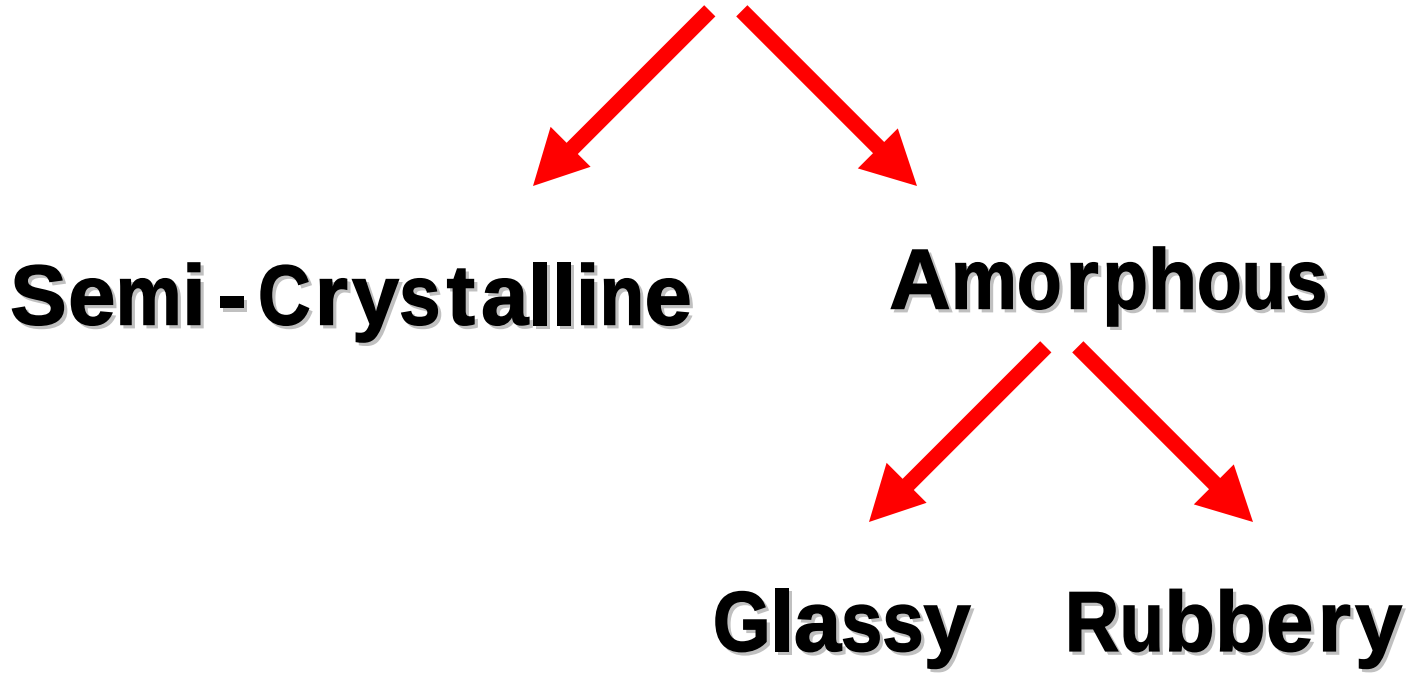
Polymer "Solid" State



Q: Relationship to Microstructure

Q: Relationship of Structure to Properties

Morphology

THE STUDY OF FORM AND STRUCTURE

Polymer morphology - the study of
Order within macromolecular solids

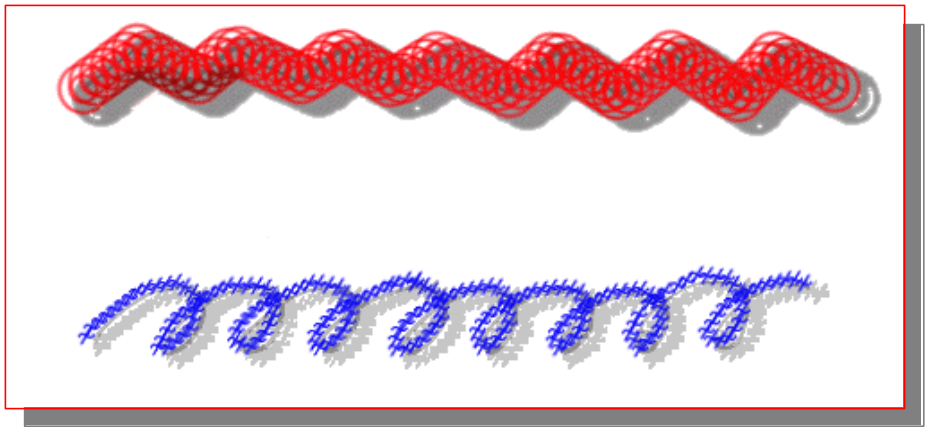
Our focus;

Morphology of semi - crystalline
Polymers

Single crystal lamellae
Spherulites
Fibers

Conformations

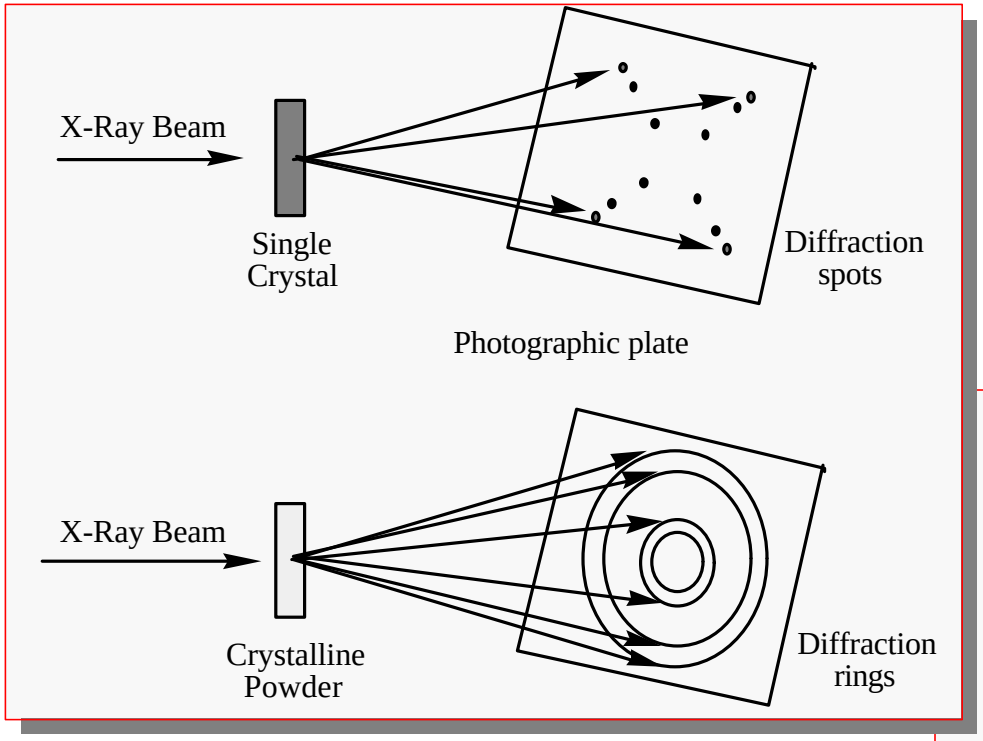
Ordered



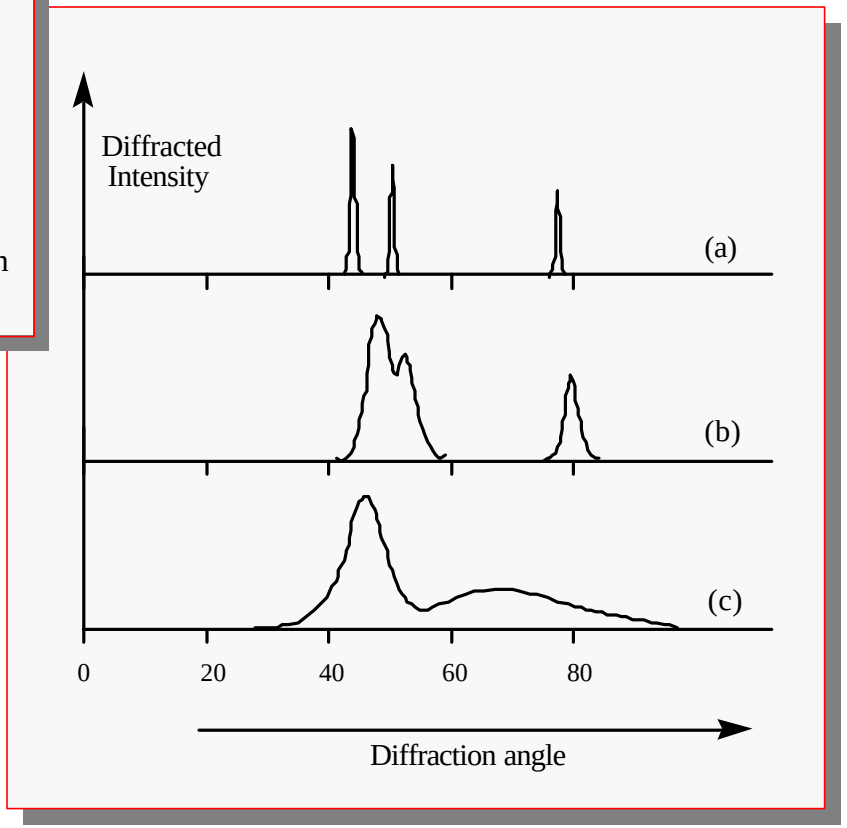
Disordered

X-Ray Diffractions

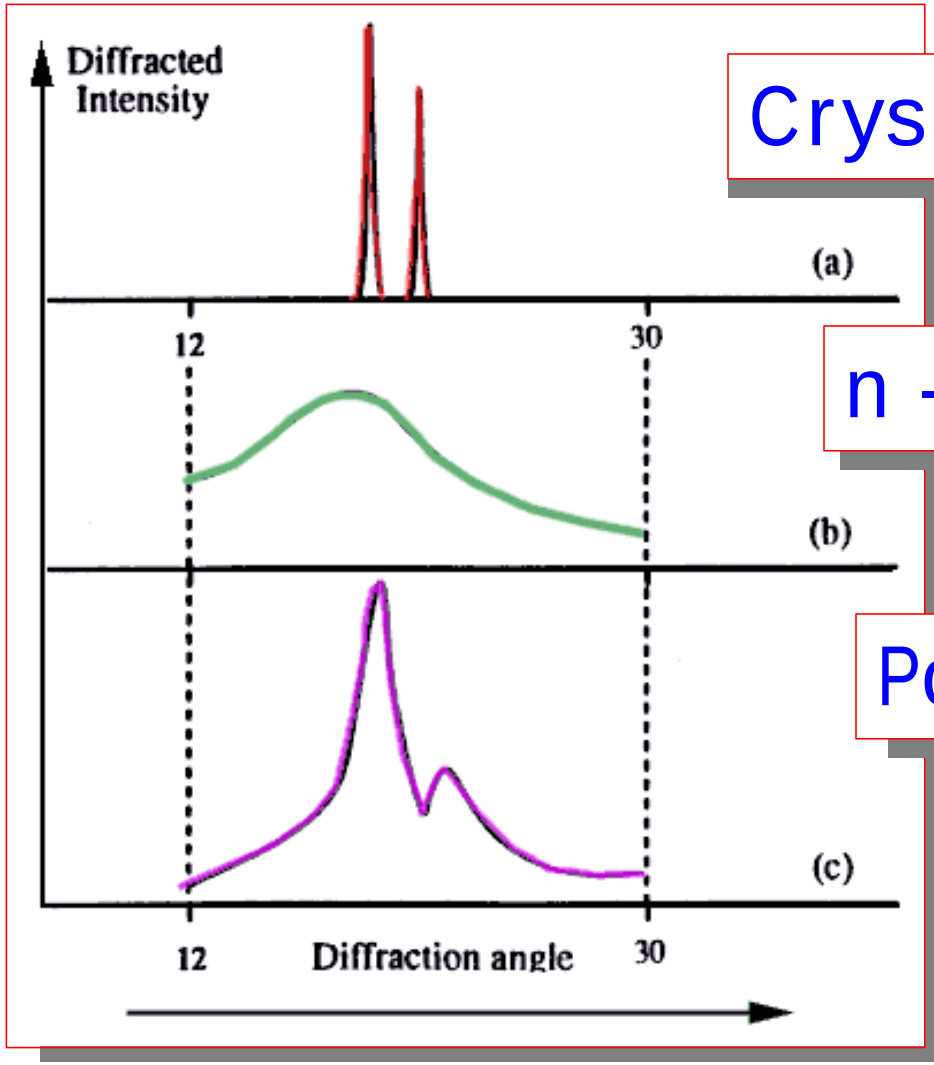
The Experiment



Diffractograms



X-Ray Diffraction : Parrafins & Polyethelene



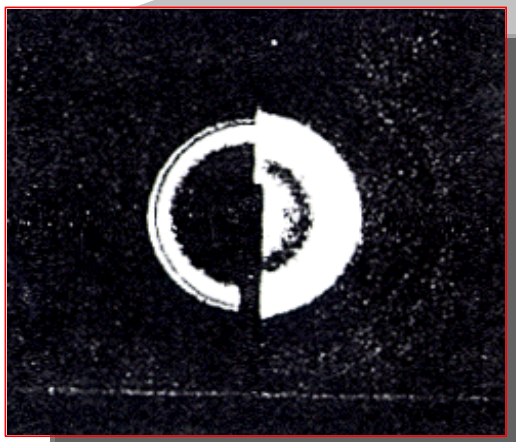
Crystalline n - Alkanes

n - Alkanes in the Melt

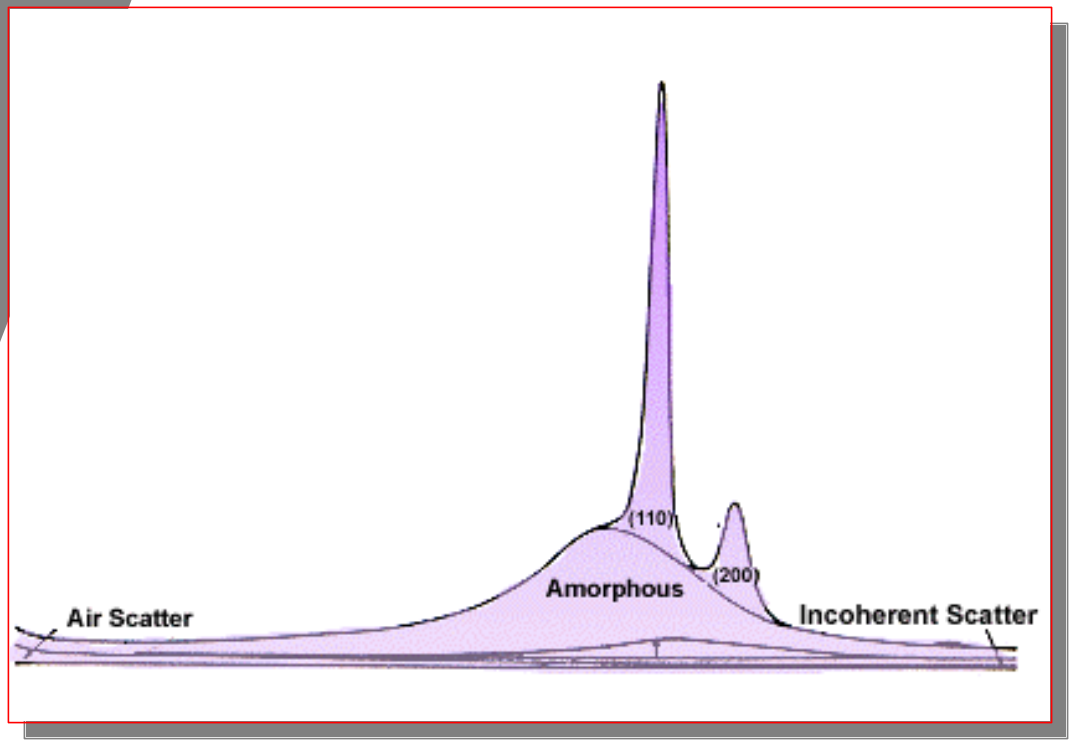
Polyethylene

X-Ray Diffraction

Powder Pattern



Diffractogram



- **CRYSTALLINE MATERIALS**
  - ***Either crystalline (100 %, neglecting defects) or amorphous at a particular temperature***
  - ***Melt at a sharp, well-defined temperature***

- **CRYSTALLIZABLE POLYMERS**
  - ***Never 100% Crystalline***
  - ***Melt over a Range of Temperatures***

" POLYMERS HAD LAID UPON THEM THE CURSE OF NOT OBEYING THERMODYNAMICS "

J.D.Hoffman,G.T.Davis,J.I.Lauritzen
In "Treatise on Solid State Chemistry"
N.B.Hannay,ed Vol 3, Ch7,Plenum Press
New York,1976

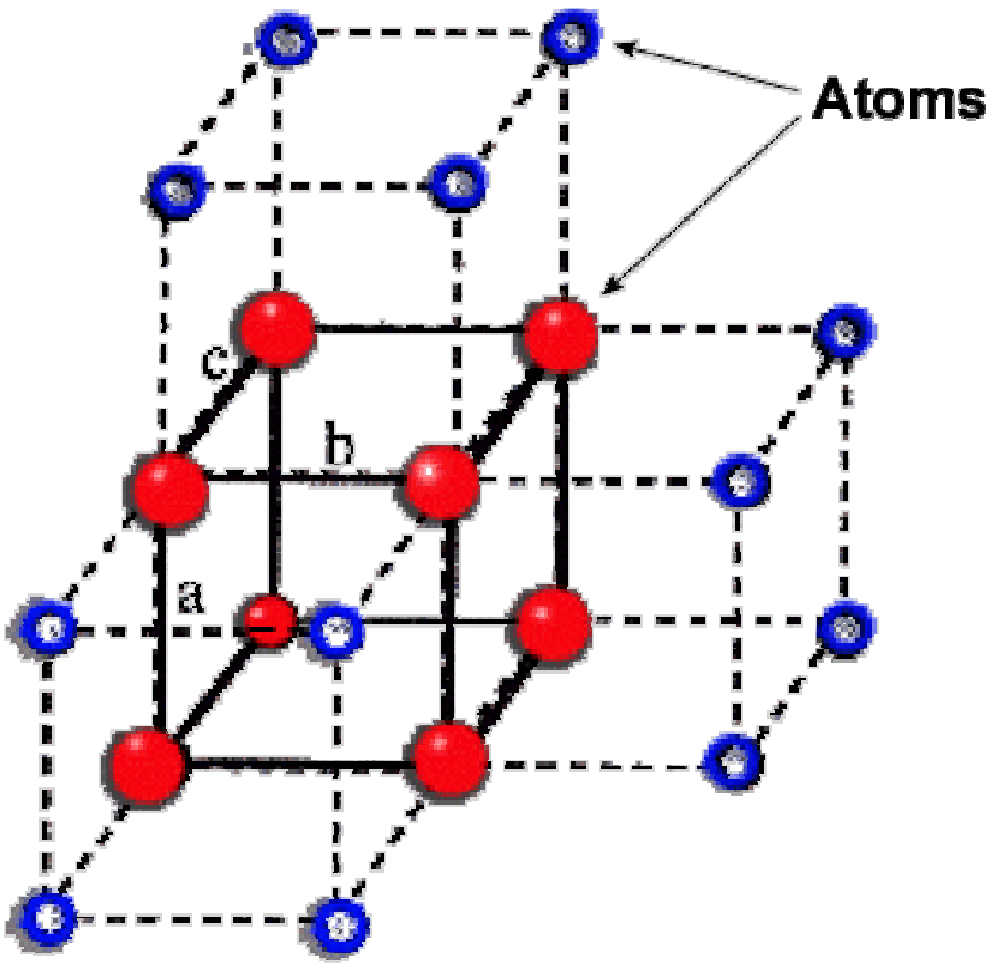
Questions

Q: What is the Conformation of the Chains in the Crystalline Domains?

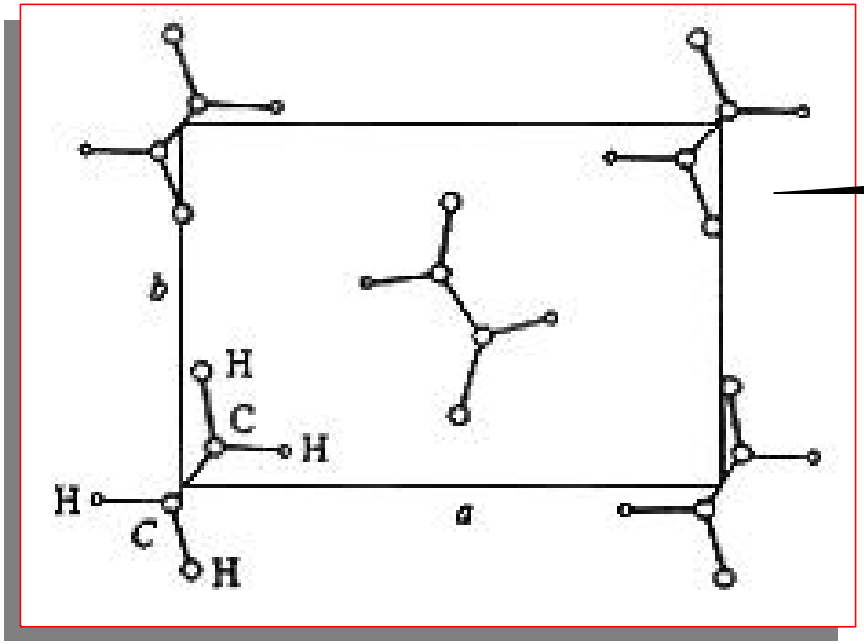
Q: What is the Overall Shape and Form of the Crystals?

Q: What are the Relative Arrangement of the Crystalline and Amorphous Parts?

The Unit Cell



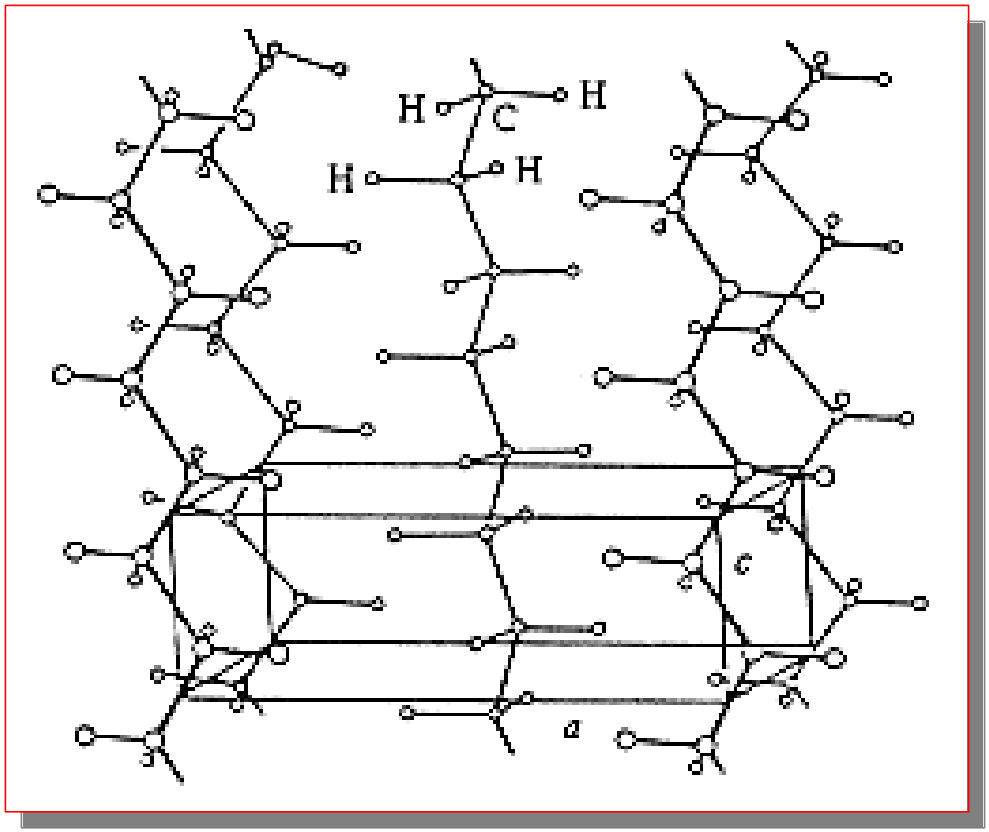
The Entire Crystal Can Be Constructed From This Basic Unit.



Polyethelene

Reproduced with permis-sion from C. W. Bunn, Fibers from Synthetic Polymers, *R. Hill, Ed., Elsevier Publishing Co., Amsterdam, 1953.*

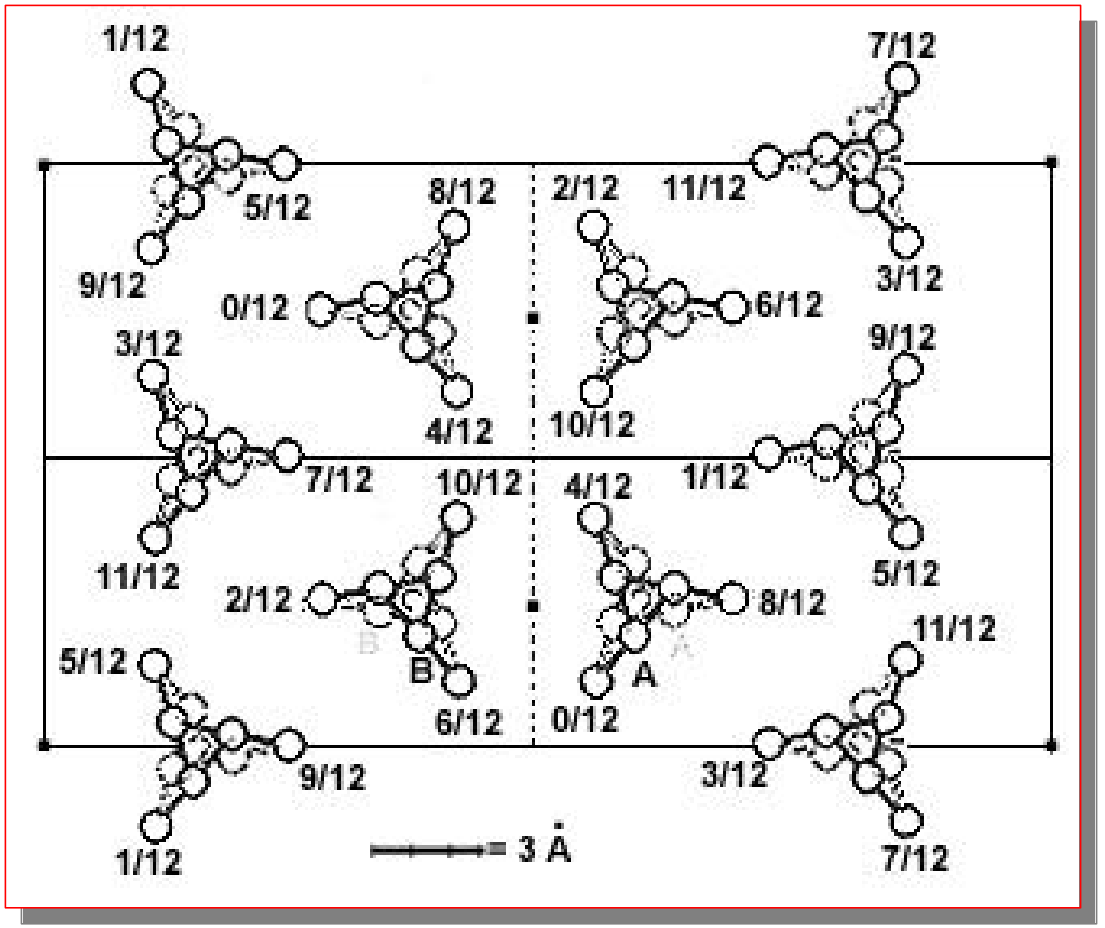
The unit cell contains small segments of different chains



Isotactic Polypropylene

Q: Would Atactic Polypropylene Be Able to Crystallize?

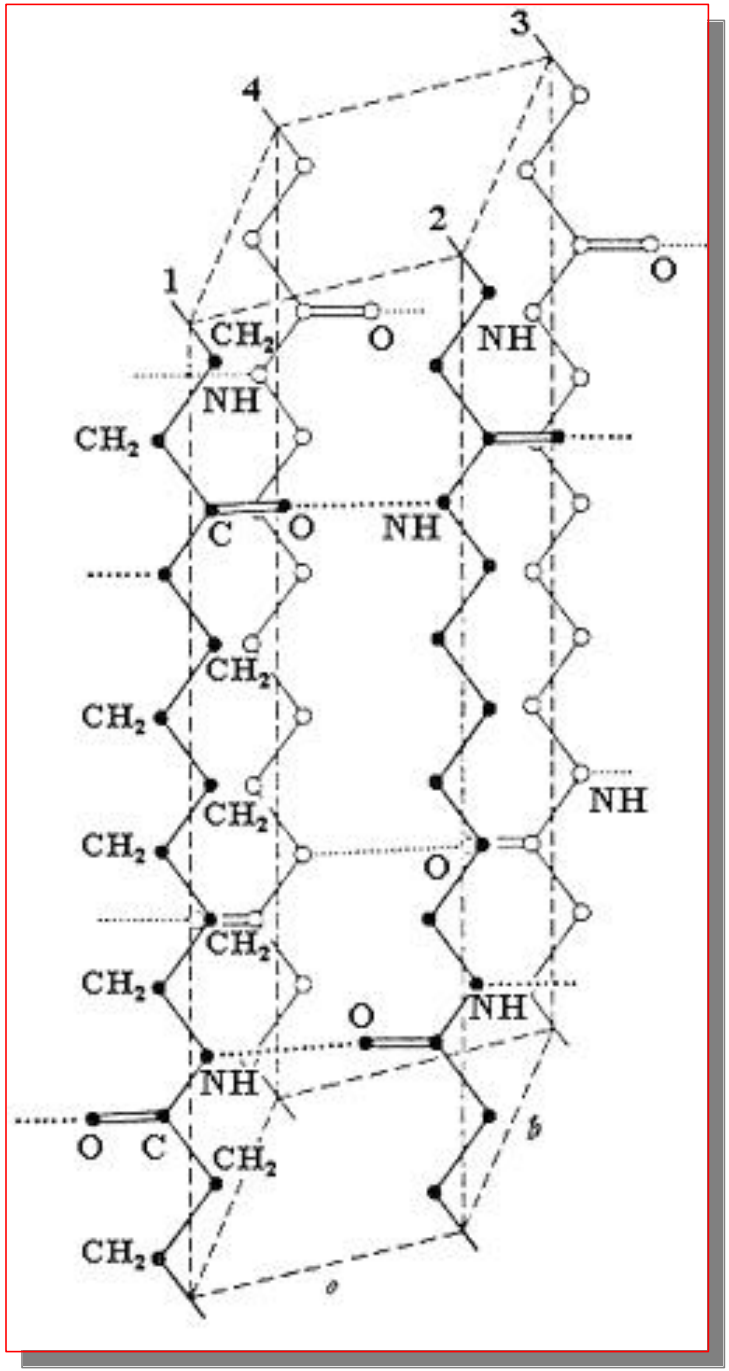
Q: What is the Basic Requirement for Crystallization?



. *Reproduced with permission from G. Natta and P. Corradini,* Nuovo Cimento, *Suppl. to Vol. 15, 1, 40 (1960).*

Nylon

The Chains Stack so as to Allow All Amide Groups to Hydrogen Bond.



. Reproduced with permis-sion from C. W. Bunn and E. V. Garner, *Proc. Roy. Soc. (London)*, **189A**, 39 (1947).