INTRODUCTION TO LIQUID CRYSTALS

What different phases

Solid Phase

- Molecules with both orientation and positional orders, and are held to each other strongly

Liquid Phase

- Molecules with no orientation and positional orders, but are held together by weak intermolecular forces

Gas Phase

- No ordering, no intermolecular attraction

Introduction to Liquid Crystals

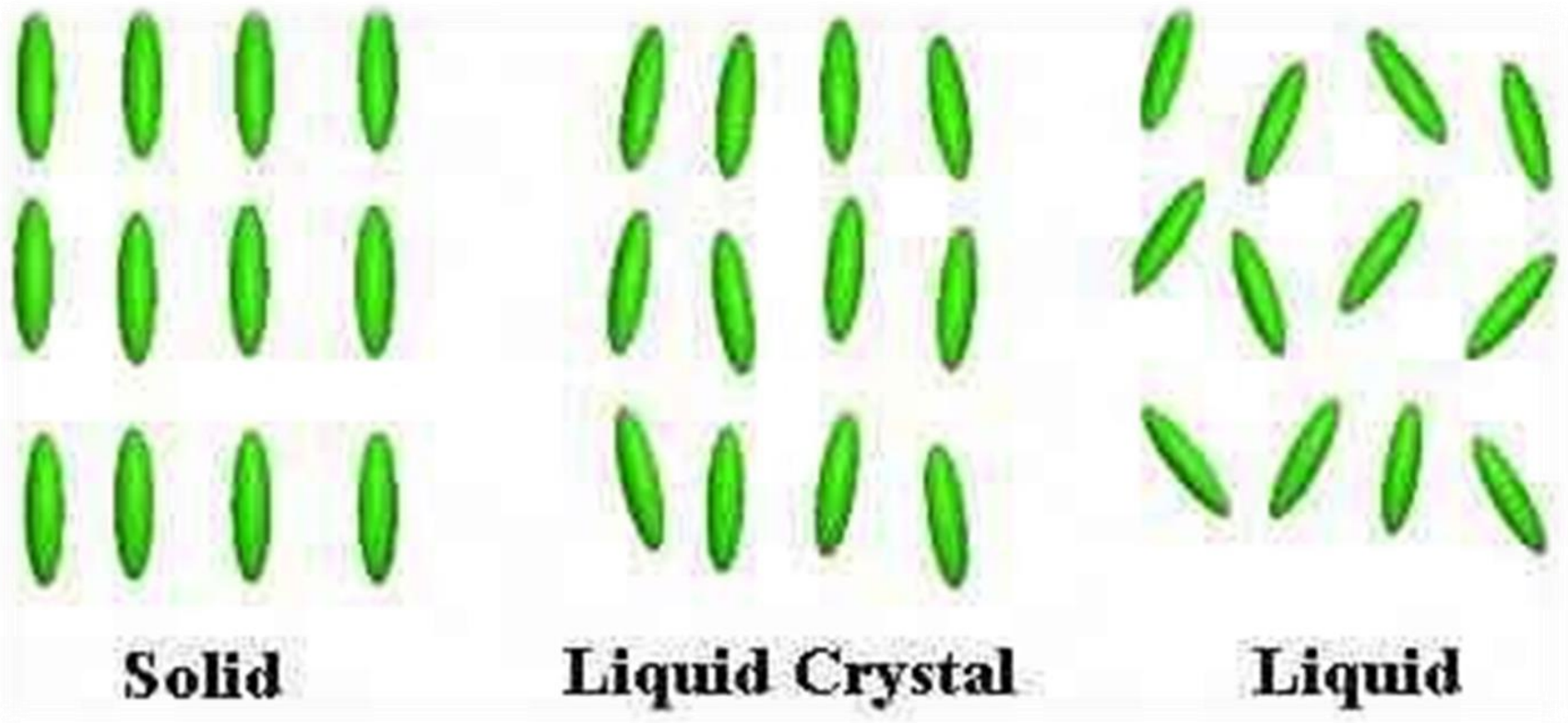
In 1988, Austrian Botanist Friedrich Reinitzer

- ⇨ **to study the role of cholesterol in plants**
- ⇨ **Found two melting point 145.5 ºC and at 178.5 ºC.**

- Liquid Crystals are soft condensed matters discovered in 1888 by Physicist Otto Lehmann.\

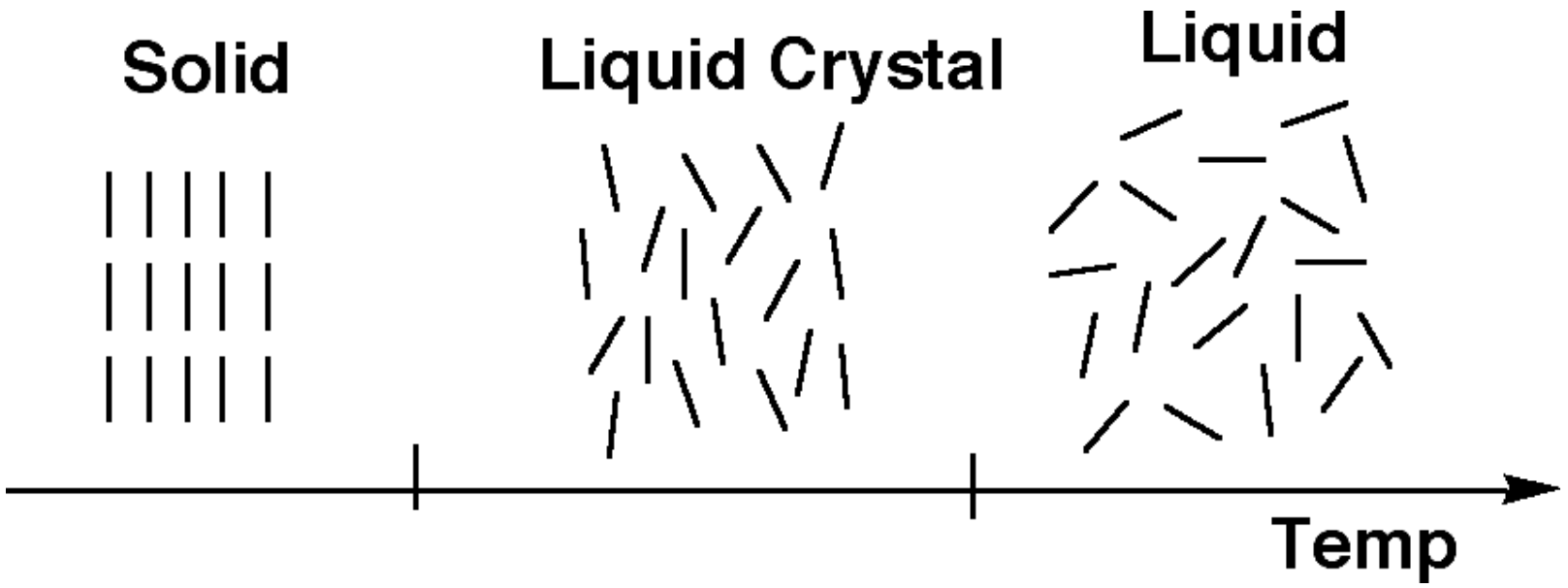
- Positional order may be lost, but some of orientational order remains.

- Also referred as *mesophase.*

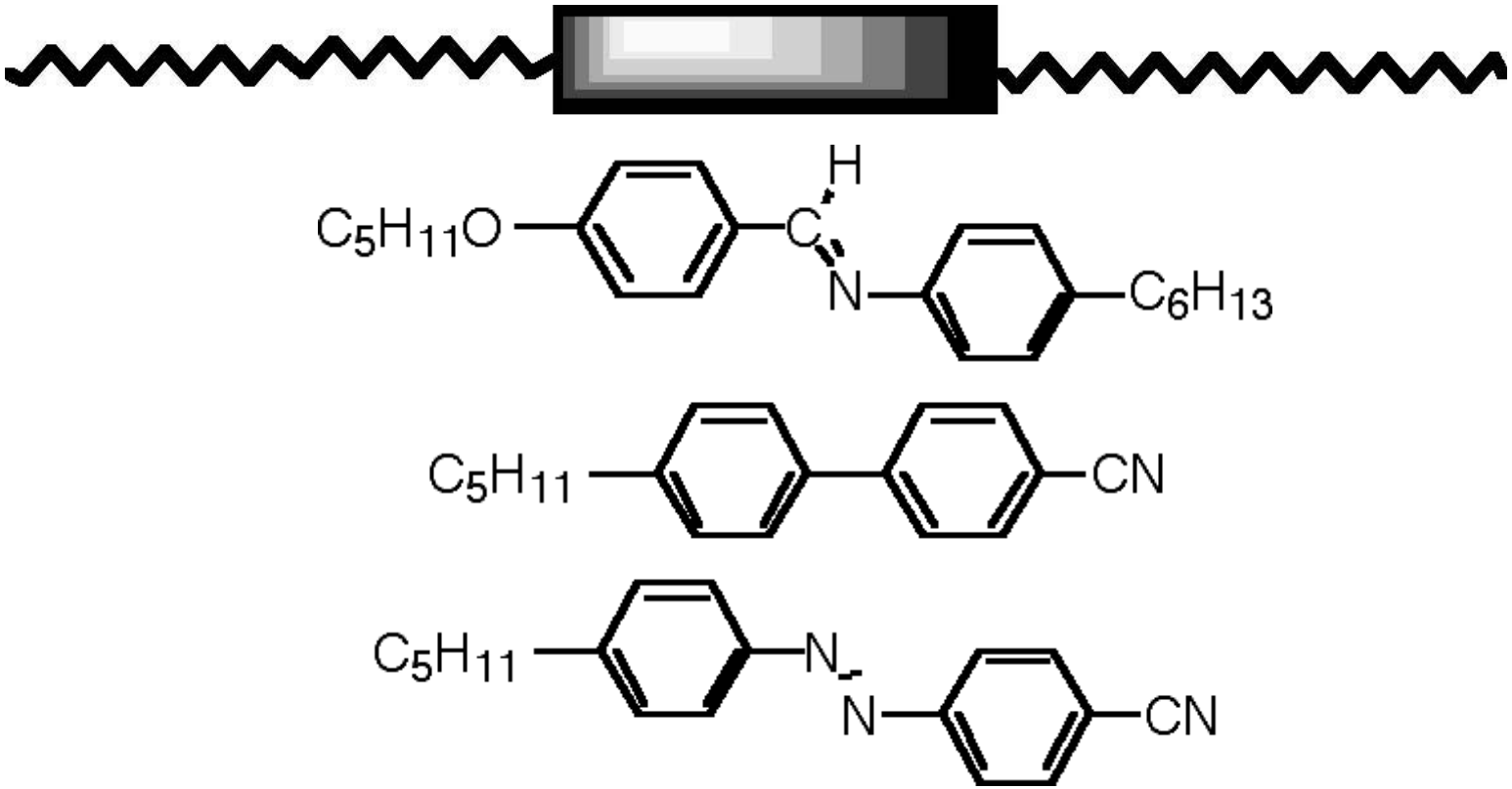

Solid
Liquid Crystal
Liquid

Liquid Crystal Phase

- A fluid phase in which a liquid crystal flows and will take the shape of its container. It differs from liquid that there are still some orientational order possessed by the molecules



Typical representation of a LC molecule



Mesogens

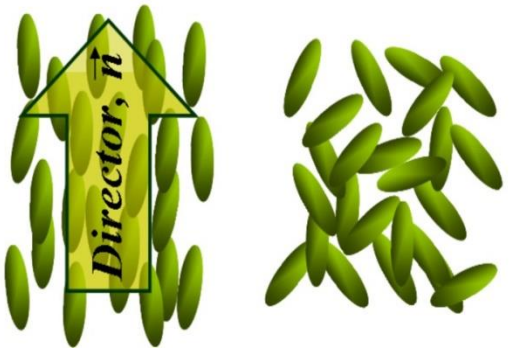
Note: these molecules possess very strong dipole moment

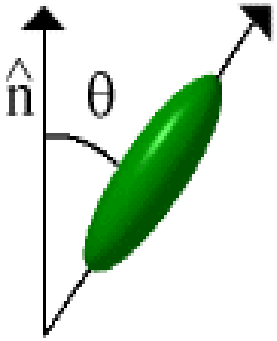
Criteria for a molecule being liquid crystalline

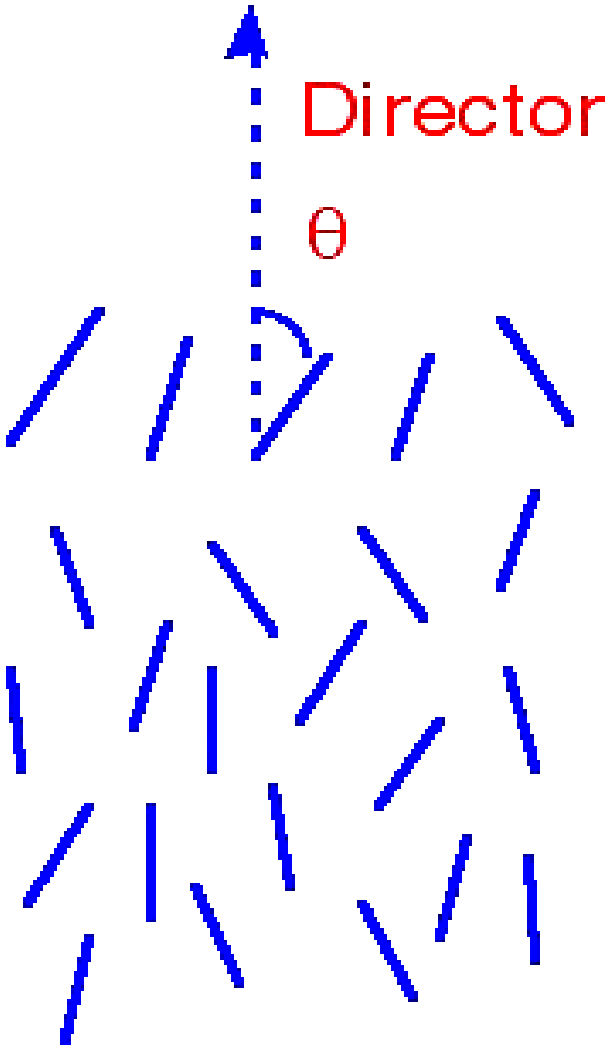
- The molecule must be elongated in shape-length should be significantly greater than its width
- Molecule must have some rigidity in its central region
- The ends of the molecule are somewhat flexible

Director

Assuming that the direction of preferred orientation in a liquid crystal (LC) is ↑, this direction can be represented by an arrow, called the *director* of the LC.







Order Parameter

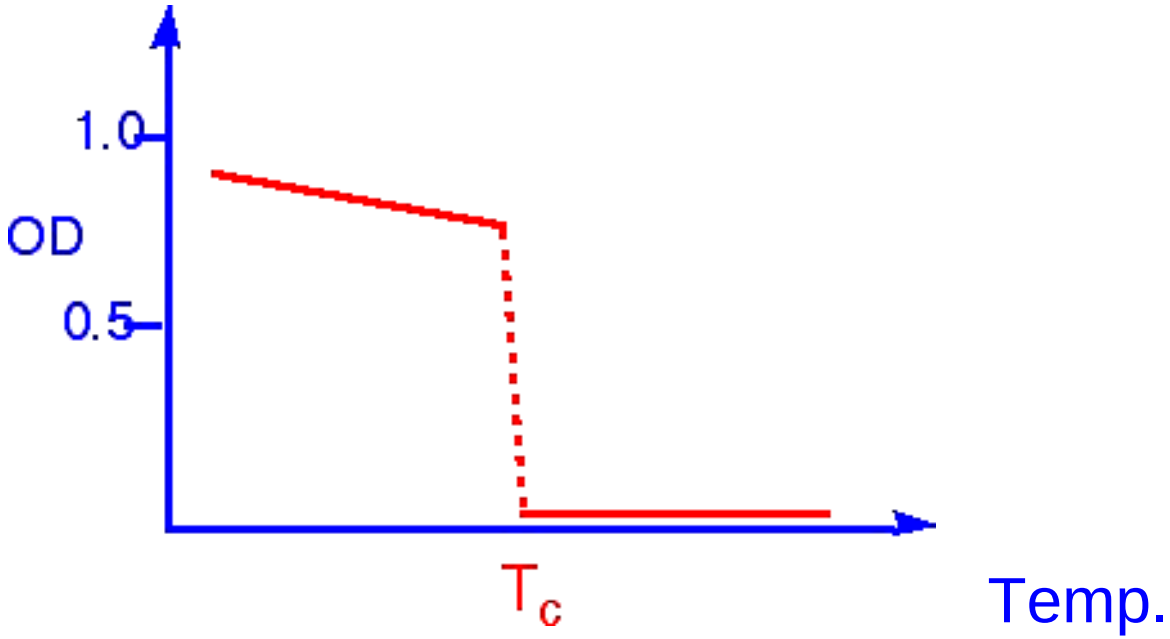
- Each molecule is orientated at some angle to the director
- We could measure all the angles and obtain the average angle as a measure of the degree of orientational order, which increases as $\theta \rightarrow 0$.

Order parameter (S): $\left\langle \frac{3\cos^2 - 1}{2} \right\rangle$

Perfect orientation: θ for all molecules = 0°, OD = 1

Completely random orientation: OD = 0

- The order parameter decreases as the temperature is increased
- Typical values of OD are ~ 0.3 to 0.9



T_c: transition temperature from LC to liquid state

Types of Liquid Crystals

Thermotropic Liquid Crystals

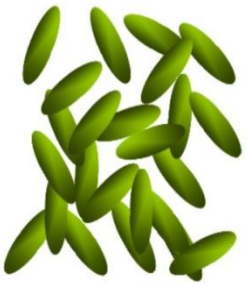
- LC phase transitions resulted from temperature changes

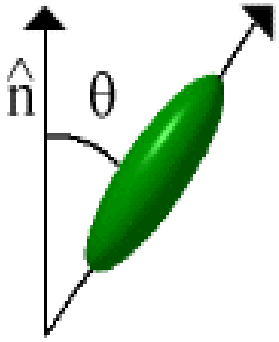
Lytropic Liquid Crystals

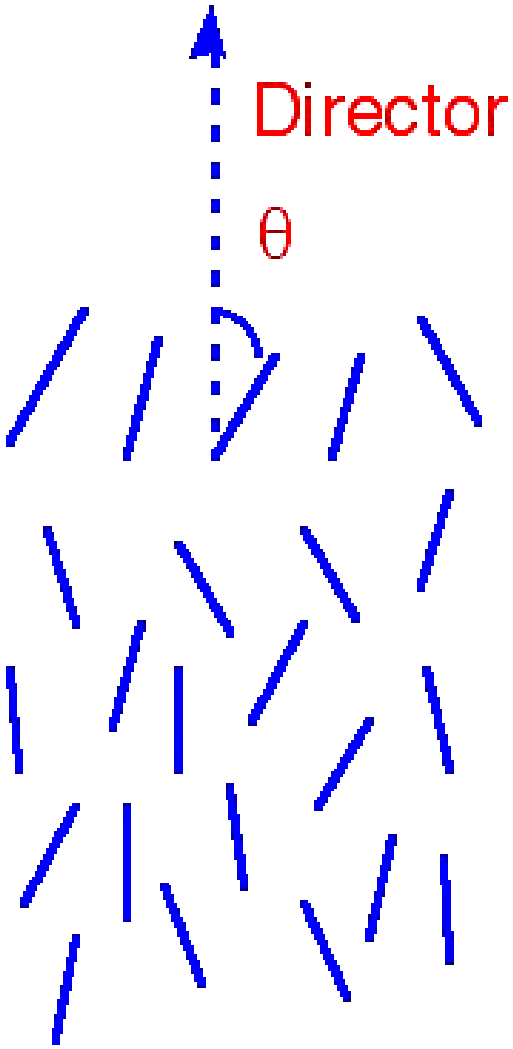
- LC phase is formed when a molecule is dissolved in a suitable solvent (with specific concentration at a particular temperature)

Orientational Order

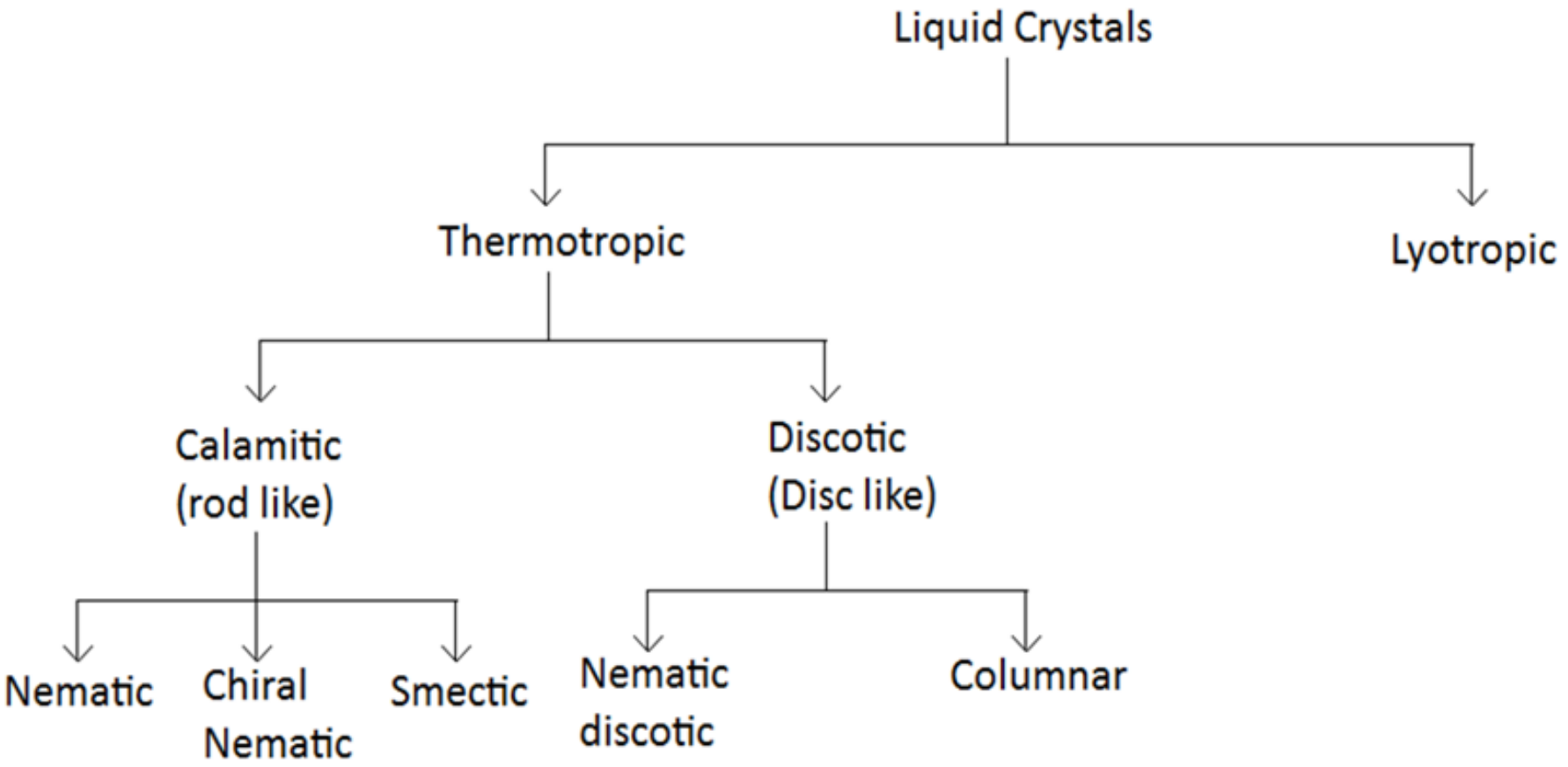
- Assuming that the direction of preferred orientation in a liquid crystal (LC) is ↑, this direction can be represented by an arrow, called the *director* of the LC.





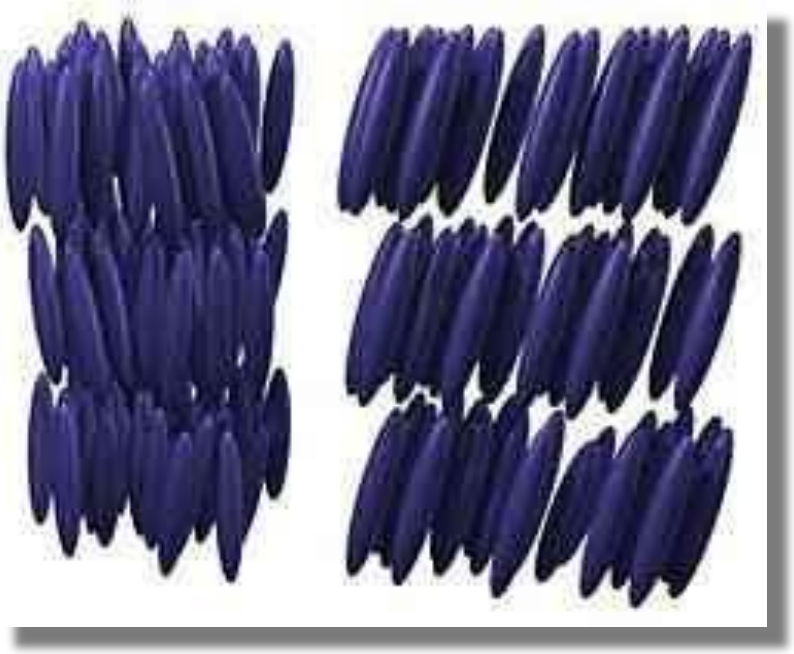


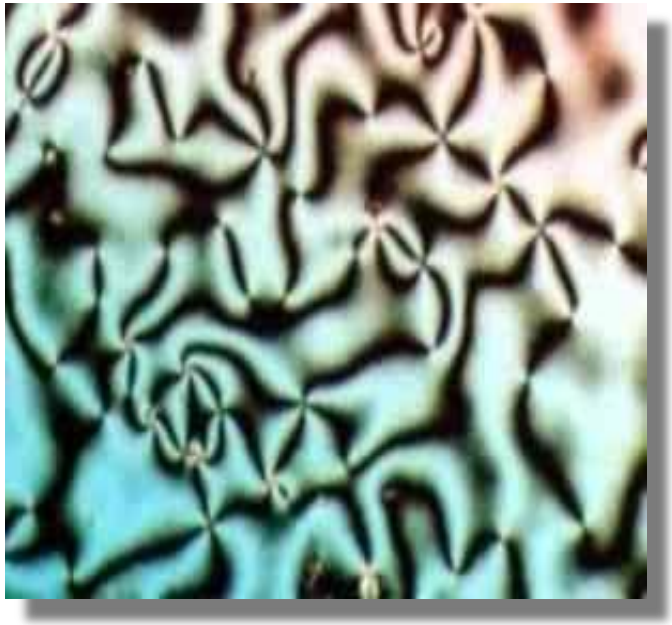
CLASSIFICATION OF LIQUID CRYSTALS



NEMATIC LIQUID CRYSTALS

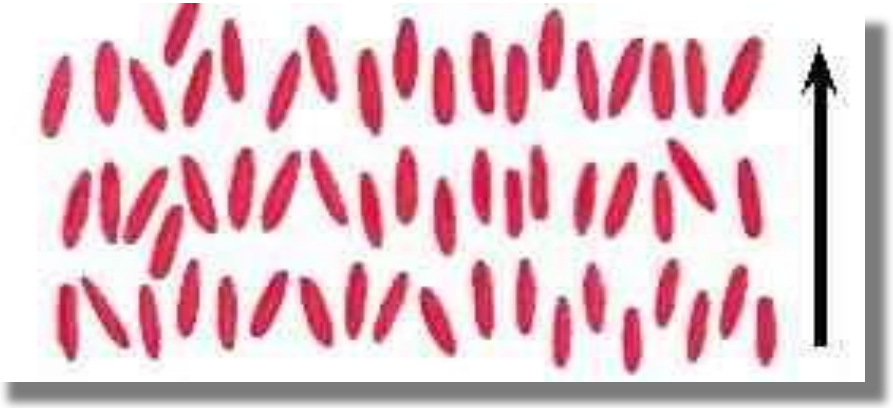
- **means ‘thread like’.**
- **tend to orient along the director.**





SMECTIC LIQUID CRYSTALS

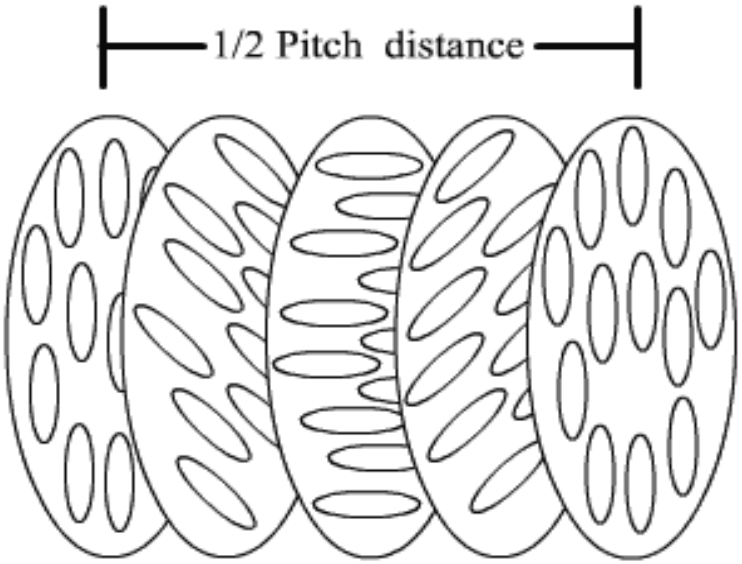
- means ‘soapy’
- general orientational order of nematic but also tend to align themselves in layers or planes.

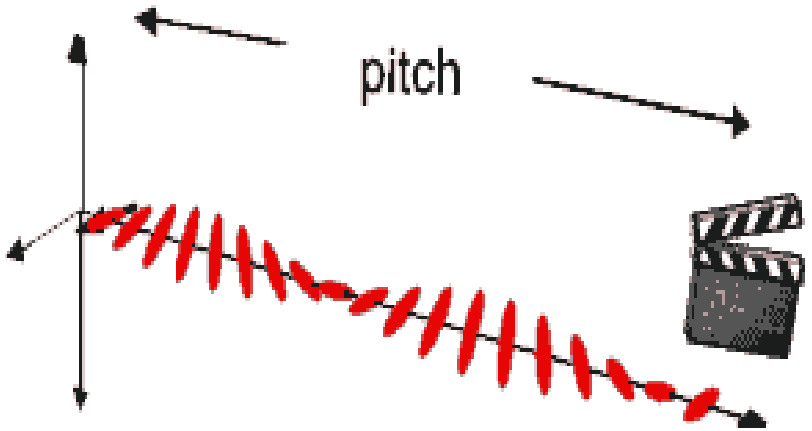


Picture of the smectic

CHIRAL NEMATIC LIQUID CRYSTAL

- formed by compounds having Chiral centers.
- directors actually form in a continuous helical pattern .





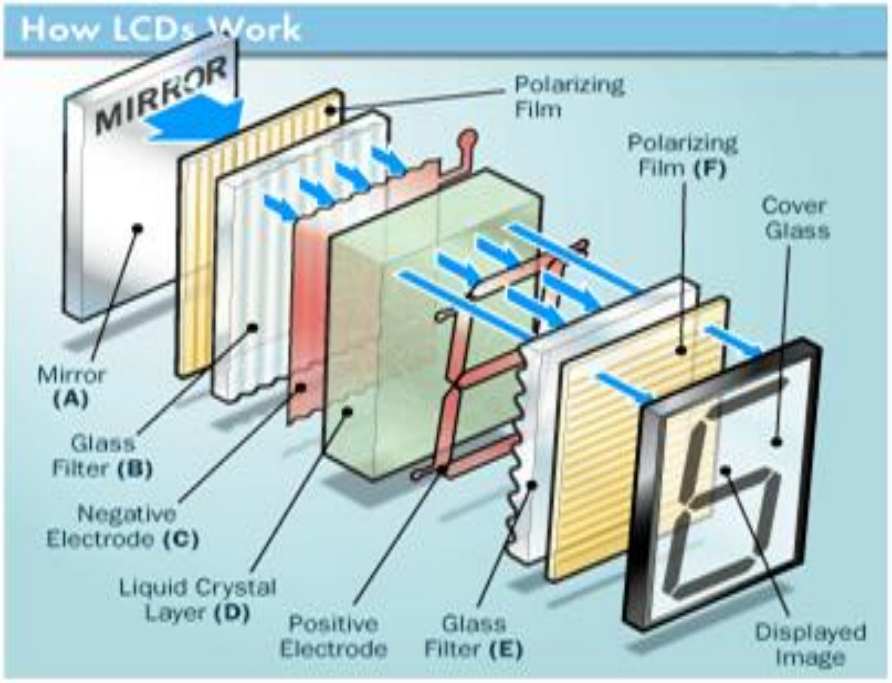
Applications of liquid Crystals

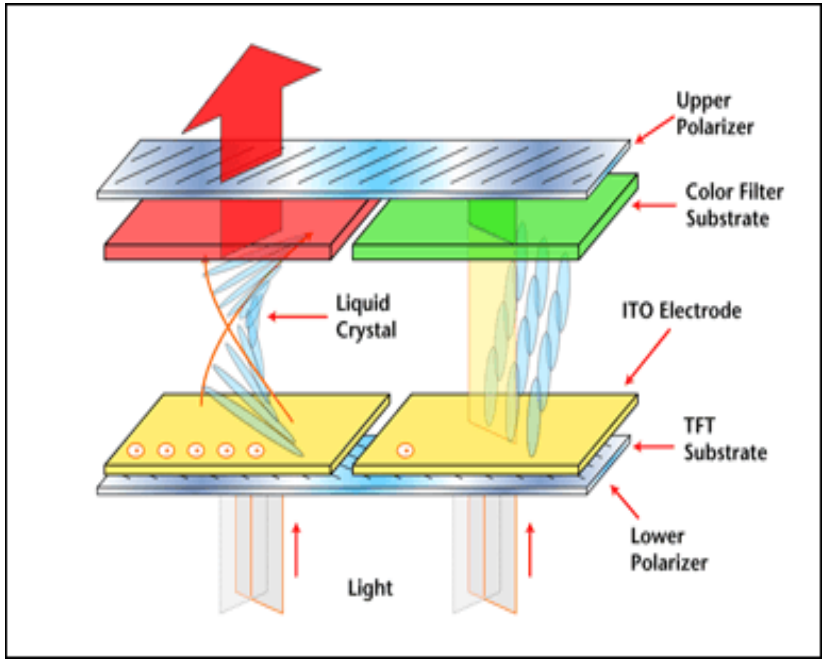
Applications of Liquid Crystals

- LCD (Liquid crystal display)
- Liquid crystal thermometer
- Liquid crystal lenses
- Liquid crystal laser
- Optical Images
- Medicinal Uses
- Helmets and bullet proof Jackets
- Optical memories

Liquid Crystal Display(LCD)

Liquid Crystal Display(LCD) screen works on the principle of blocking light rather than emitting light. LCD's requires backlight as they do not emits light by them.





ADVANTAGES OF LCD

Brightness	Produces very bright images due to high peak intensity. Very suitable for environments that are brightly lit .
Emissions	Produce considerably lower electric, magnetic and electromagnetic fields than CRTs.
Geometric Distortion	No geometric distortion at the native resolution. Minor distortion can occur for other resolutions.
Power Consumption	Energy efficient. Consume less than 1/3 the power of a comparable CRT. Consume less electricity than a CRT and produce little heat.
Physical Aspects	Take up about 40% less desk space. LCDs are thin and compact.
Screen Shape	Completely flat screen.
Sharpness	At the native resolution, the image is perfectly sharp. Adjustments are required at all other resolutions which can result in measurable degradation to the image.