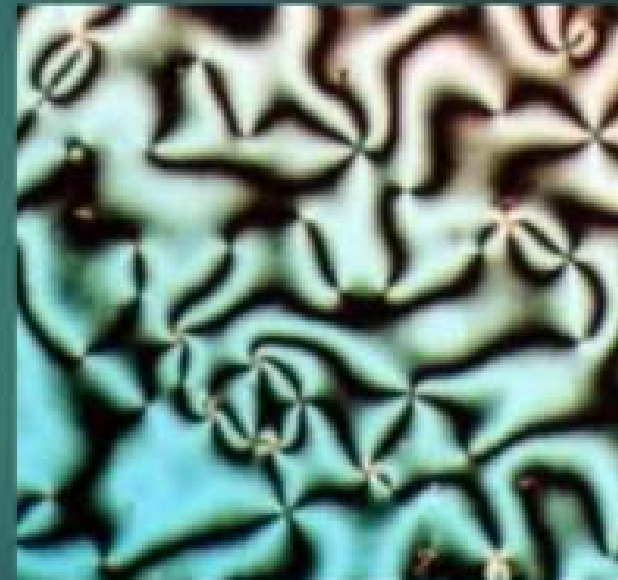


LIQUID CYRSTALS

1.INTRODUCTION

- ▶ A liquid crystal may flow like a liquid, but its molecules may be oriented in a crystal-like way.
- ▶ There are many different types of liquid-crystal phases, which can be distinguished by their different optical properties such as **birefringence**.
- ▶ When viewed under a microscope using a polarized light source, different liquid crystal phases will appear to have distinct textures.



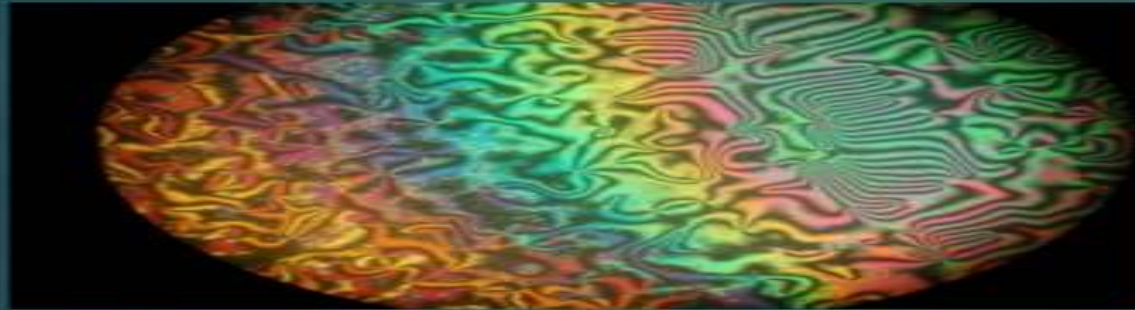
- The contrasting areas in the textures correspond to domain where the LC molecules are oriented in different directions.



- Within a domain , however the molecules are well ordered.

Imp:- LC material may not always be in LC phase (just as water turns into ice or steam)

2. CLASSIFICATION OF LIQUID CRYSTALS

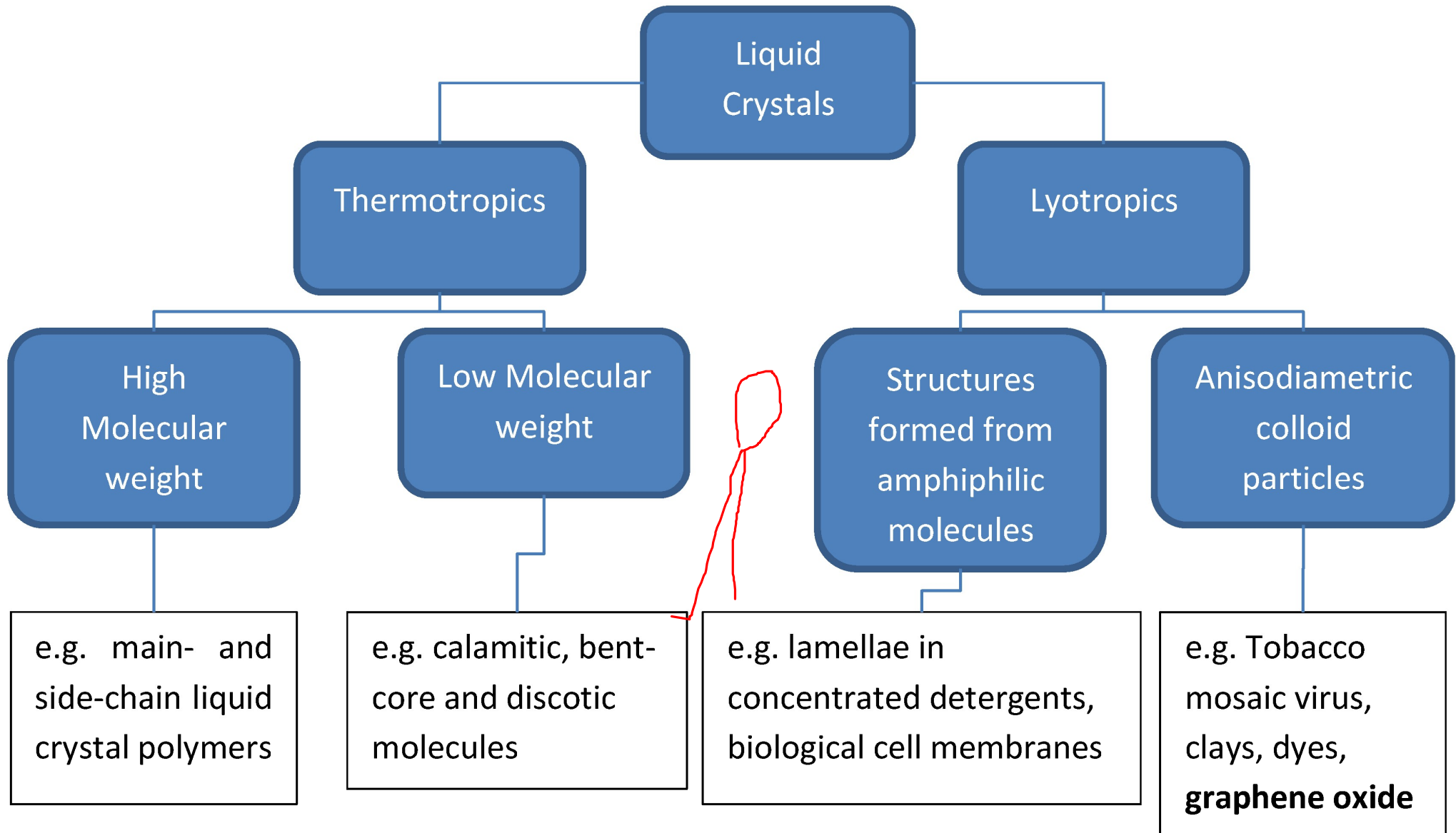


Thermotropic liquid crystals

phase forms as a function of temperature

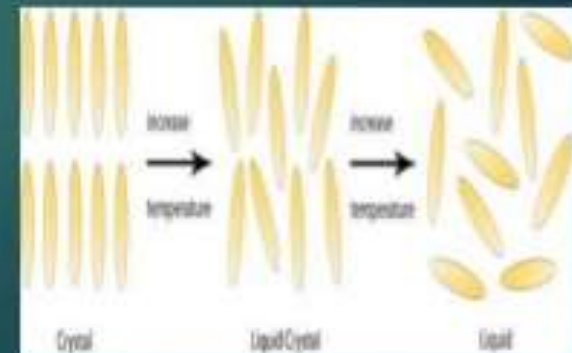
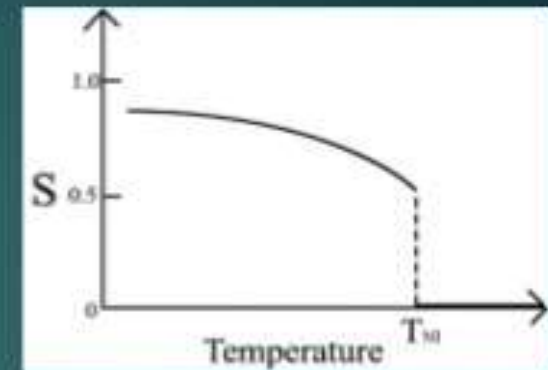
Lyotropic liquid crystals

Phase forms as a function of concentration
in a solvent



2.1. Thermotropic Liquid Crystals

- ❖ The essential requirement for a molecule to be a thermotropic LC is a structure consisting of a central rigid core (often aromatic) and a flexible peripheral moiety (generally aliphatic groups). This structural requirement leads to two general classes of LCs:

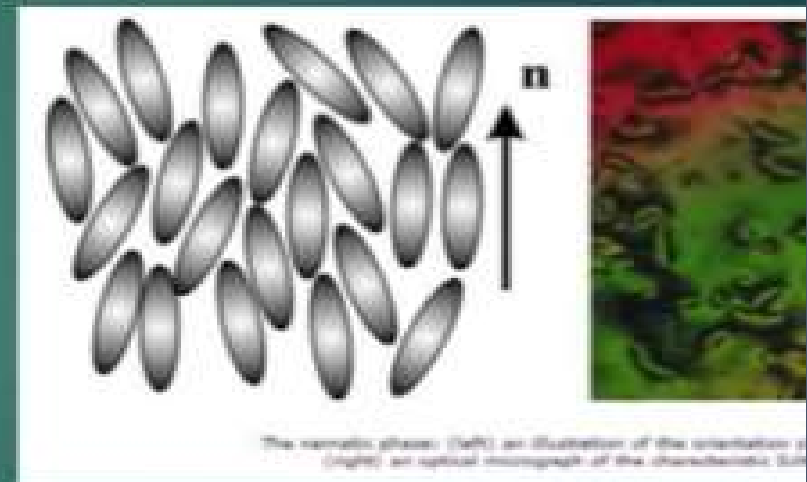


Examples of LC's

- 1) **Examples of LC's can be found both in natural world & in technological application.**
- 2) **Most contemporary electronic displays uses liquid crystals.**
- 3) **Lyotropic liquid crystalline phase are abundant in living system.**
- 4) **Many protein and cell membranes are LC's.**
- 5) **Other examples is solution of soap & various related detergent, as well as tobacco mosaic virus.**

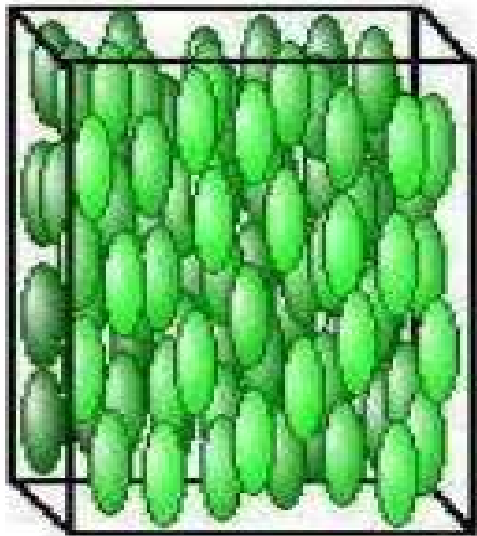
Nematic Phase (No translational order)

- ❖ The word "Nematic" is derived from the Greek word for thread-like structure.
- ❖ It is the only liquid crystal phase with no long range translational order.
- ❖ Preferred Orientation is denoted by the 'Director' n .
- ❖ The nematic phase is one of the most common LC phases.
- ❖ It has thread like structure when seen under polarizing microscope.



Nematic Phases

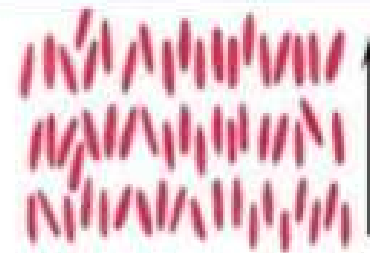
The nematic liquid crystal phase is characterized by molecules that have no positional order but tend to point in the same direction (along the director). In the following diagram, notice that the molecules point vertically but are arranged with no particular order.



A schematic representation of the nematic phase (left) and a photo of a nematic liquid crystal (above).

Smectic Phase (One-dimensional translational)

- ❖ The word "Smectic" is derived from the Greek word for soap
- ❖ Liquid-like motion of the rods in each layer
- ❖ No correlation of the molecular positions from one layer to the next
- ❖ The layers can easily slide
- ❖ In the smectic A phase, molecules tend to be perpendicular to the smectic layers
- ❖ In the smectic C phase, the molecules in the layers are parallel and tilted in arrangement with respect to the normal of the layers by a tilt angle θ .



Picture of the smectic A phase



Photo of the smectic A phase
(using polarizing microscope)



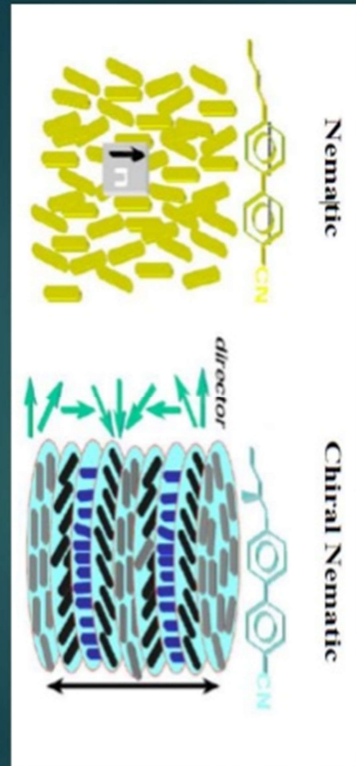
Picture of the smectic C phase



Photo of the smectic C phase
(using polarizing microscope)

Chiral Phase (Cholesteric Phase)

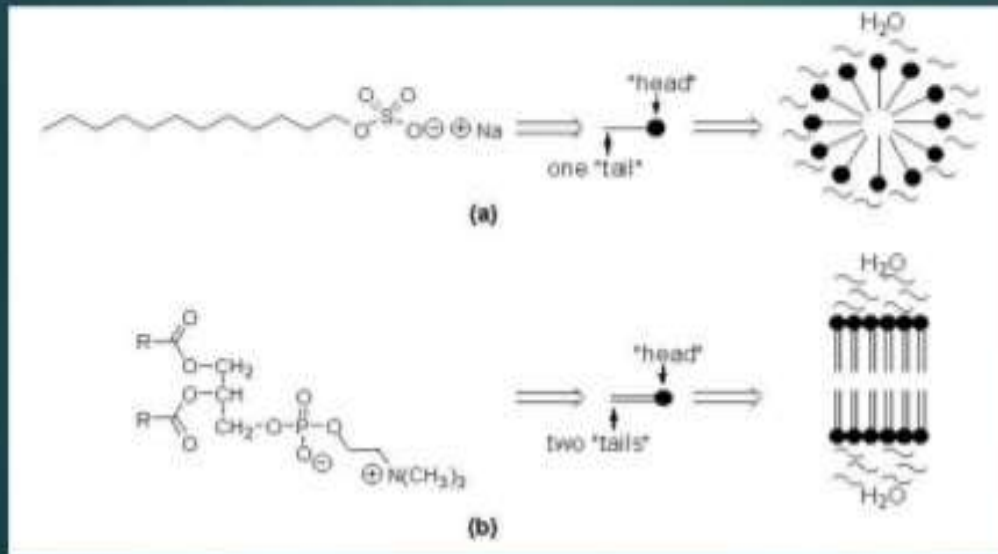
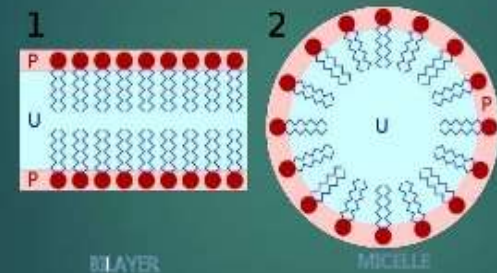
- ❖ Also known as "Chiral nematic"
- ❖ Molecules have non-symmetrical carbon atoms and thus lose mirror symmetry
- ❖ Shows a helical structure.
- ❖ In general the helical pitch of cholesteric liquid crystals is of the order of visible light's wavelength—about a few hundreds nm and so shows different color.



2.2. Lyotropic Liquid Crystals

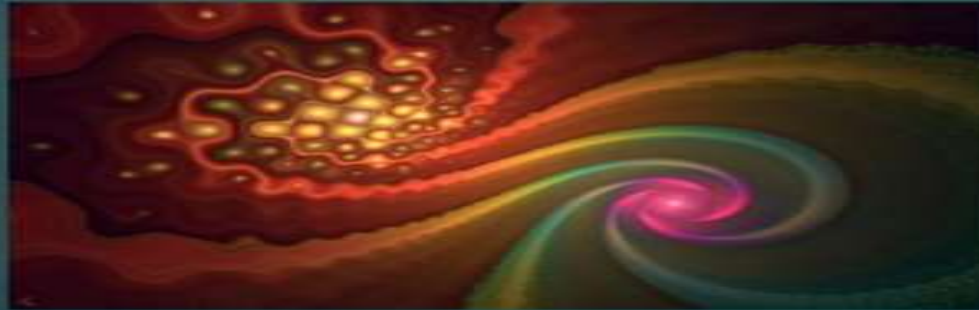
- ❖ Lyotropic LCs are two-component systems where an amphiphile is dissolved in a solvent.
- ❖ Lyotropic mesophases are concentration and solvent dependent.

A compound that has two immiscible hydrophilic and hydrophobic parts within the same molecule is called an amphiphilic molecule.



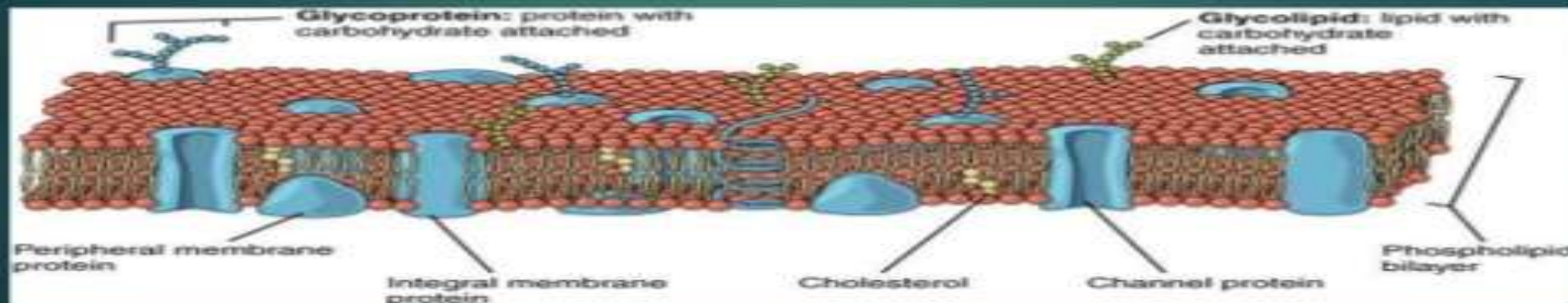
Soap is an everyday example of a lyotropic liquid crystal. Soap





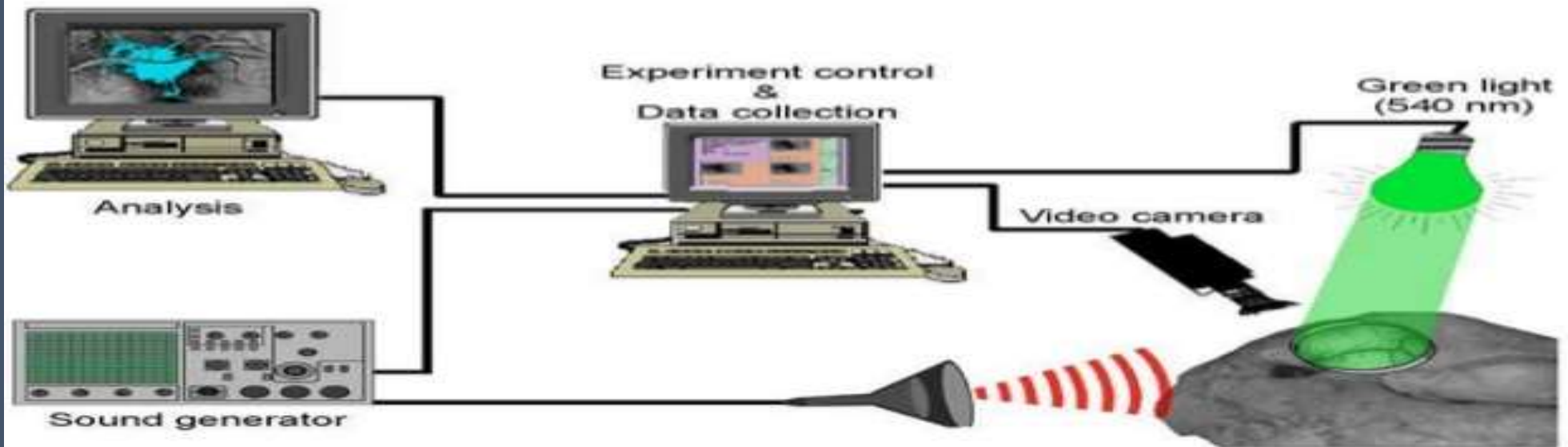
BIOLOGICAL LIQUID CRYSTALS

In particular, biological membranes and cell membranes are a form of liquid crystal. Their constituent molecules (e.g. phospholipids) are perpendicular to the membrane surface, yet the membrane is flexible. These lipids vary in shape.



Optical Imaging

- Optical Imaging is an emerging technology with great potential for improving disease prevention, diagnosis, and treatment in the medical office, at the bedside, or in the operating room



Applications of Liquid crystals

1. Optical fibers making, telecommunication use.
2. Electrical and electronics applications.
3. Transport, automotive, military applications.
4. Aircraft and aerospace applications. (Lenses)
5. Chemical and consumer appliances. (optical electrodes, sun glasses etc)
6. Reinforcement of plastics for obtaining fiber plastics which are very strong (as fillers and and for composites)
7. They are used as displays in digital wrist-watches, calculators, panel meters, and industrial products.
8. They can be used to record, store, and display images which can be projected onto a large-screen.They also have potential use as television displays.

The two features which make them more desirable for displays than other materials are lower power consumption and the clarity of display in the presence of bright light.

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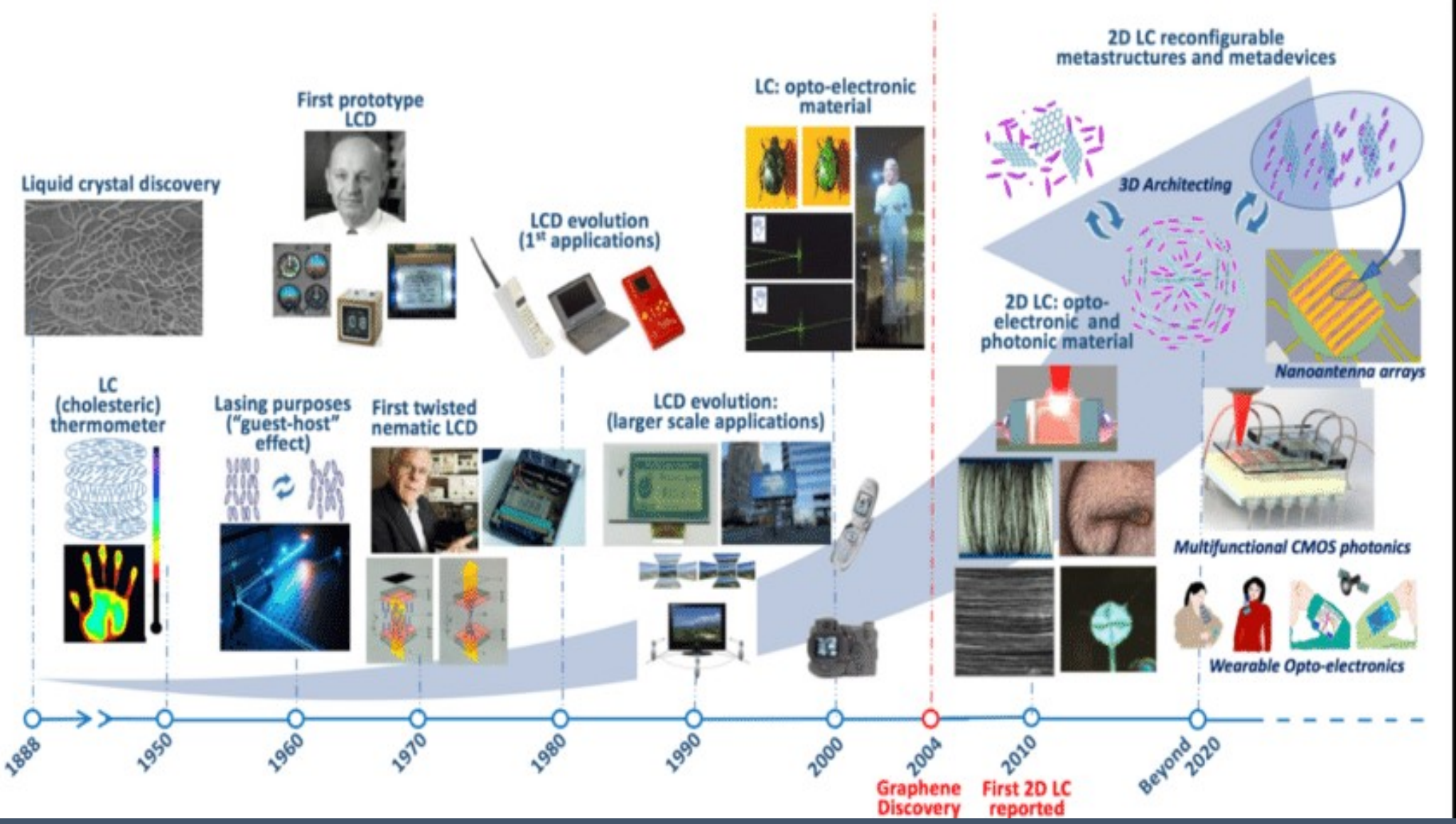
The two modes most widely used in liquid crystal displays are **dynamic-scattering and field-effect**

MINERAL LIQUID CRYSTALS

- Examples of liquid crystals can also be found in the mineral world, most of them being lyotropics. The first discovered was V_2O_5 , by Zocher in 1925.

- Zeolite





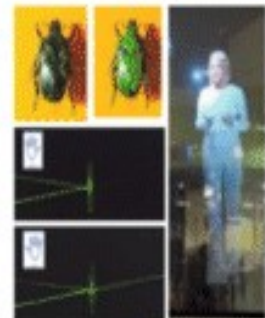
First prototype LCD



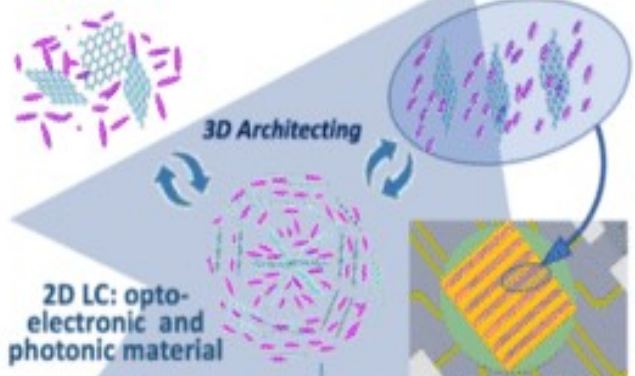
LCD evolution (1st applications)



LC: opto-electronic material



2D LC reconfigurable metastructures and metadevices



Multifunctional CMOS photonics



Wearable Opto-electronics