SNOWFLAKE GROWTH

VARYING MICROENVIRONMENTS

SUBMITTED BY:
KREETY KHATRI (2K19/EP/045)
PULKIT PANDEY (2K19/EP/076)

Acknowledgment

Presentation, Inspiration and Motivation have always played a key role in success of any project.

We express a deep sense of gratitude to **Dr M Jayasimhadri** , Assistant Professor, Department of Applied Physics, DTU to encourage us to highest peak and to provide us with the opportunity to prepare the project. We are immensely obliged to him for his elevating inspiration, encouraging guidance and kind supervision in the completion of the project. We are also thankful for his invaluably constructive criticism and advises throughout the working of the project.

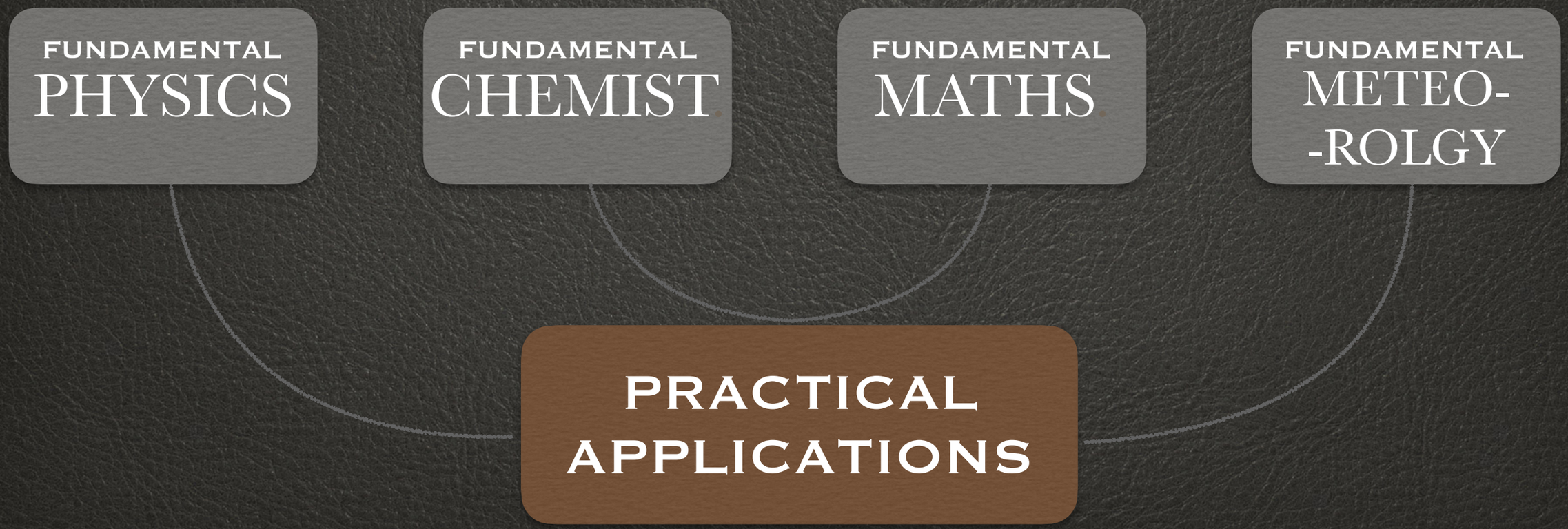
The accomplishment of the project was due to our equal efforts and contribution. We are highly indebted towards our University, that is, Delhi Technological University, New Delhi.

CONTENTS

OBJECTIVE

- TO GAIN THE KNOWLEDGE OF FUNDAMENTAL FUNCTIONING OF THE VERY ENVIRONMENT WE LIVE IN, BY MEANS OF CONDENSED MATTER PHYSICS.

- DELVING INTO THE APPLICATIVE RESEARCH ORIENTED PERSPECTIVE OF MATERIAL SCIENCES.



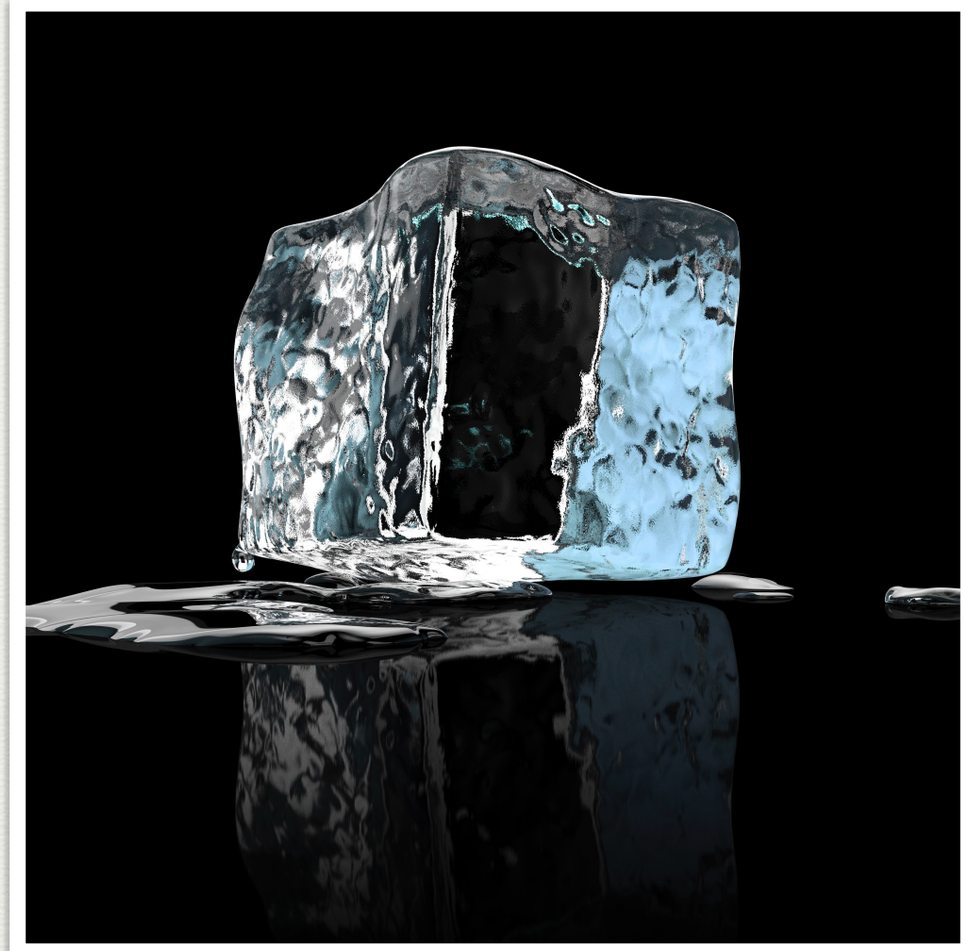
PROJECT OVERVIEW

This Project delves into the Physical Dynamics of Ice Crystal/Snow Flake Growth.

THERE are two primary physical effects that govern ice growth rates —

BASIC TERMINOLOGIES

SNOWFLAKE GROWTH



ICE SOLIDIFICATION

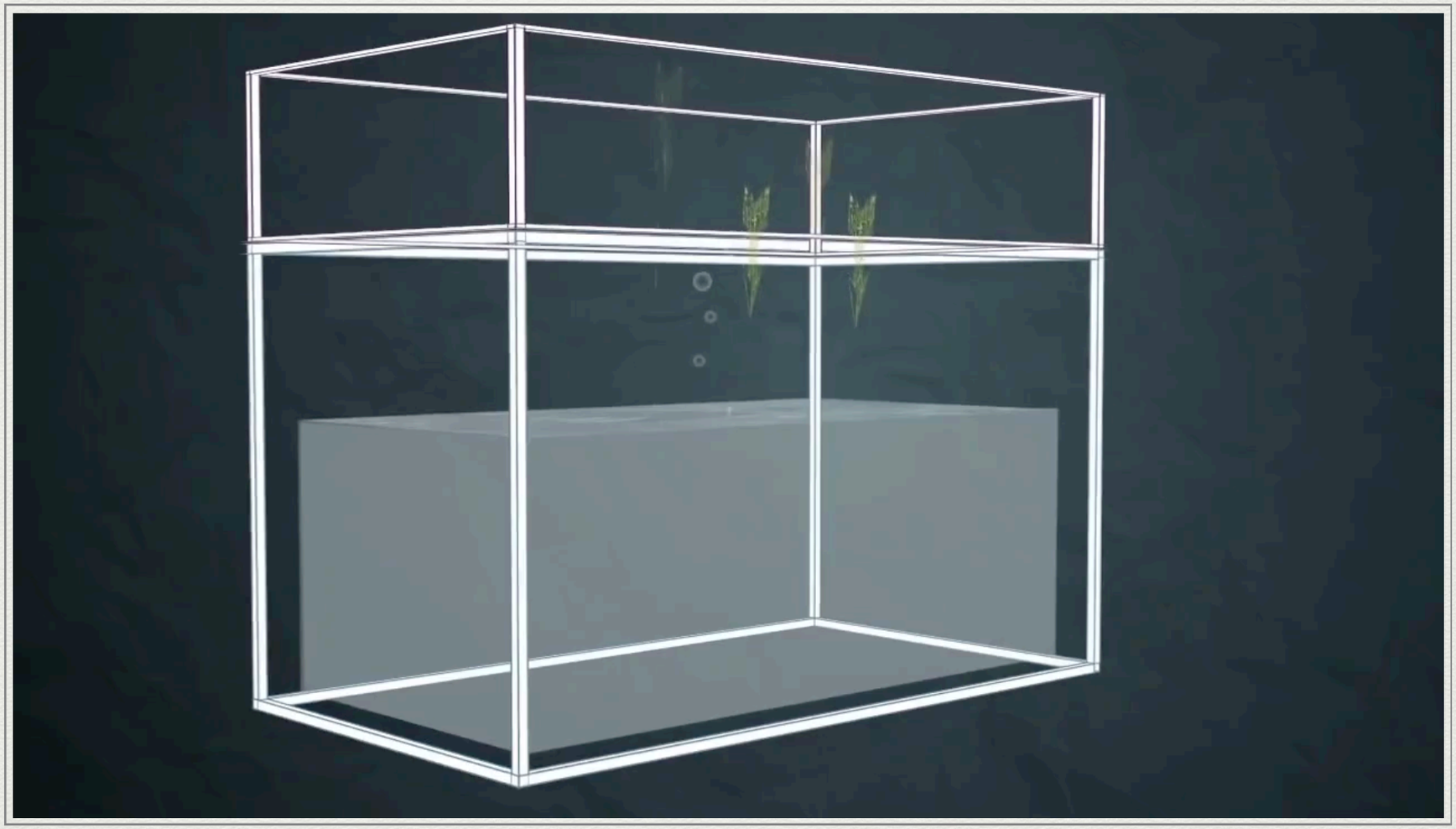
BASIC TERMINOLOGIES

SNOWFLAKE GROWTH

SUPERCOOLING

BASIC TERMINOLOGIES

SNOWFLAKE GROWTH



WATER VAPOR
SUPERSATURATION

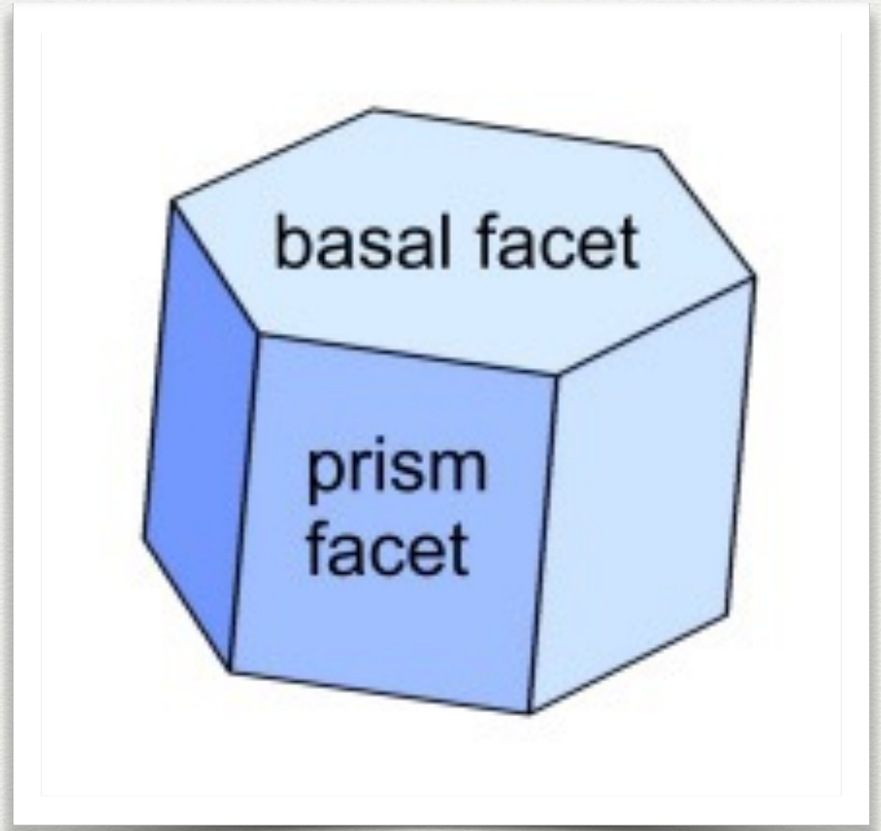
BASIC TERMINOLOGIES

SNOWFLAKE GROWTH

TRIPLE POINT

BASIC TERMINOLOGIES

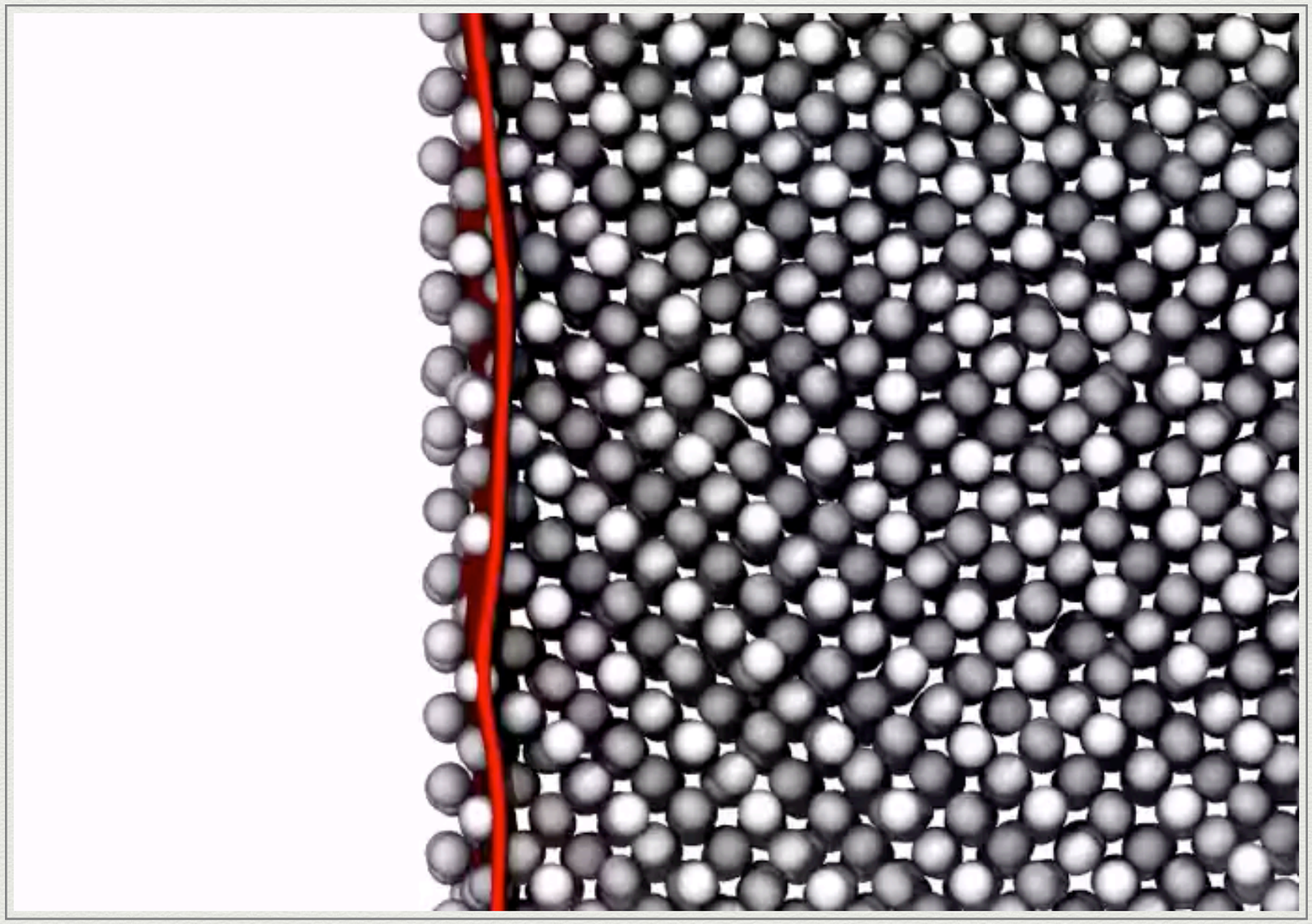
SNOWFLAKE GROWTH



BASAL FACETING

BASIC TERMINOLOGIES

SNOWFLAKE GROWTH



SURFACE PRE-MELTING

Surface Attachment Kinetics

NUCLEATION THEORY

- For a simple monomolecular solid surface, crystal growth is driven by a chemical potential jump at the interface, such as a nonzero supercooling or supersaturation.

- A general polynuclear growth model gives the normal growth velocity,

$$v_n \approx A\Delta\mu \exp(-S\beta^2 a^2 / \Delta\mu k T_{surf})$$

where v_n *is Normal Growth Velocity*

$S \approx 1$ *is a geometrical factor*

β *is the step free energy at the crystal interface*

$a = c^{-1/3} \approx 0.32$ *nm is the molecular size*

$\Delta\mu$ *is the chemical potential jump at the interface*

k is the Boltzmann factor

T_{surf} *is the interface temperature.*

FORMATION IN REVIEW

GROWTH MORPHOLOGIES

ICE GROWTH FROM LIQUID WATER

- A key variable describing the solidification of ice from liquid water is the degree of supercooling,

$$T_{surf} = T_m - T_{surf},$$

$$\text{where } T_m \approx 0°C$$

- Now, growth velocity v_n (normal to the surface) , may be defined as

$$v_n\,(T_{surf}) = K_T T_{surf}$$

- This automatically gives the equilibrium condition $v_n = 0$ when $T_{surf} = 0$, although in general K_T is also temperature dependent.
- Other parameters affecting might be surface orientation relative to the crystal axes, solute concentrations, overall crystal morphology, the presence of container walls or other foreign materials, or simply the initial conditions and/or boundary conditions describing a particular system.

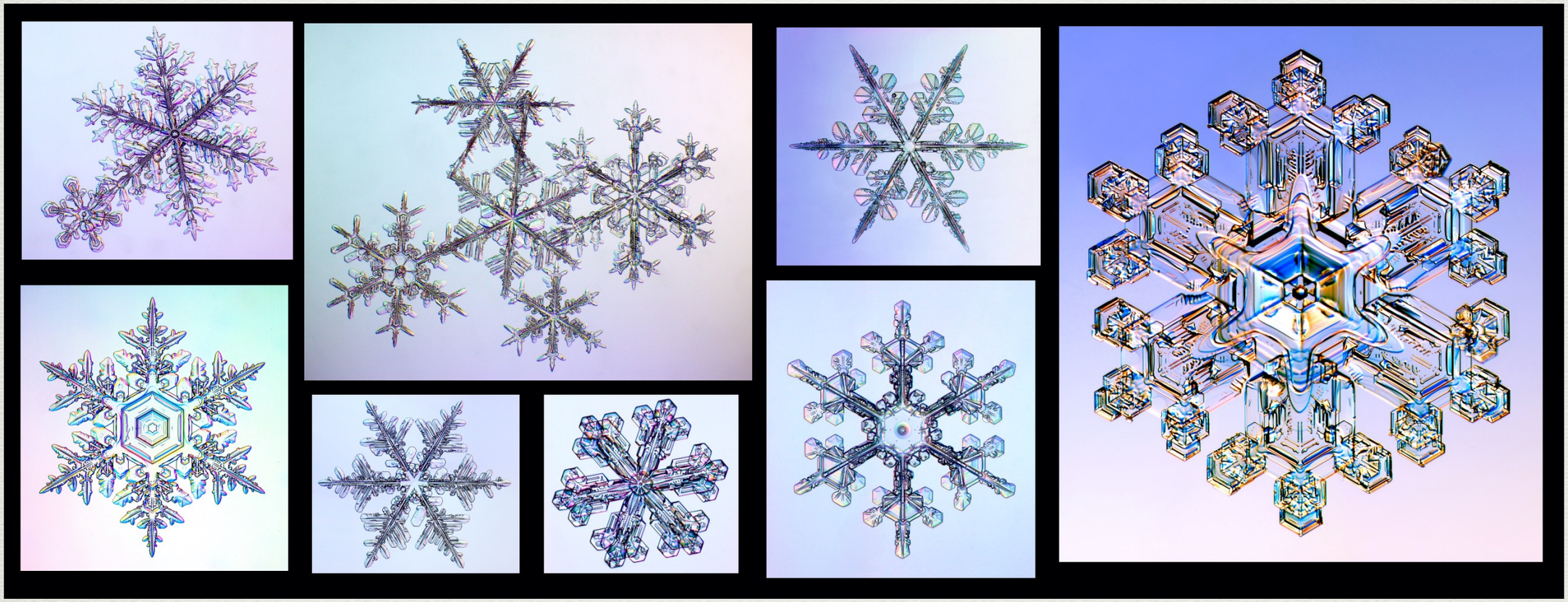
GROWTH MORPHOLOGIES

ICE GROWTH FROM LIQUID WATER

- Another commonly used measure of supercooling is $T_{bath} = T_m - T_\infty$, where T_∞ is the temperature of the supercooled water surrounding the crystal, far from the growing interface.
- Generally $T_{surf} > T_\infty$
- For a small supercooling with $T_{bath} < 1°C$, a microscopic seed crystal tends to grow into the form of a simple, circular disk.

Variation In Temperature

CIRCULAR TO DENDRITIC PLATES



$$\Delta T_{\text{bath}} < 2^{\circ}\text{C}$$

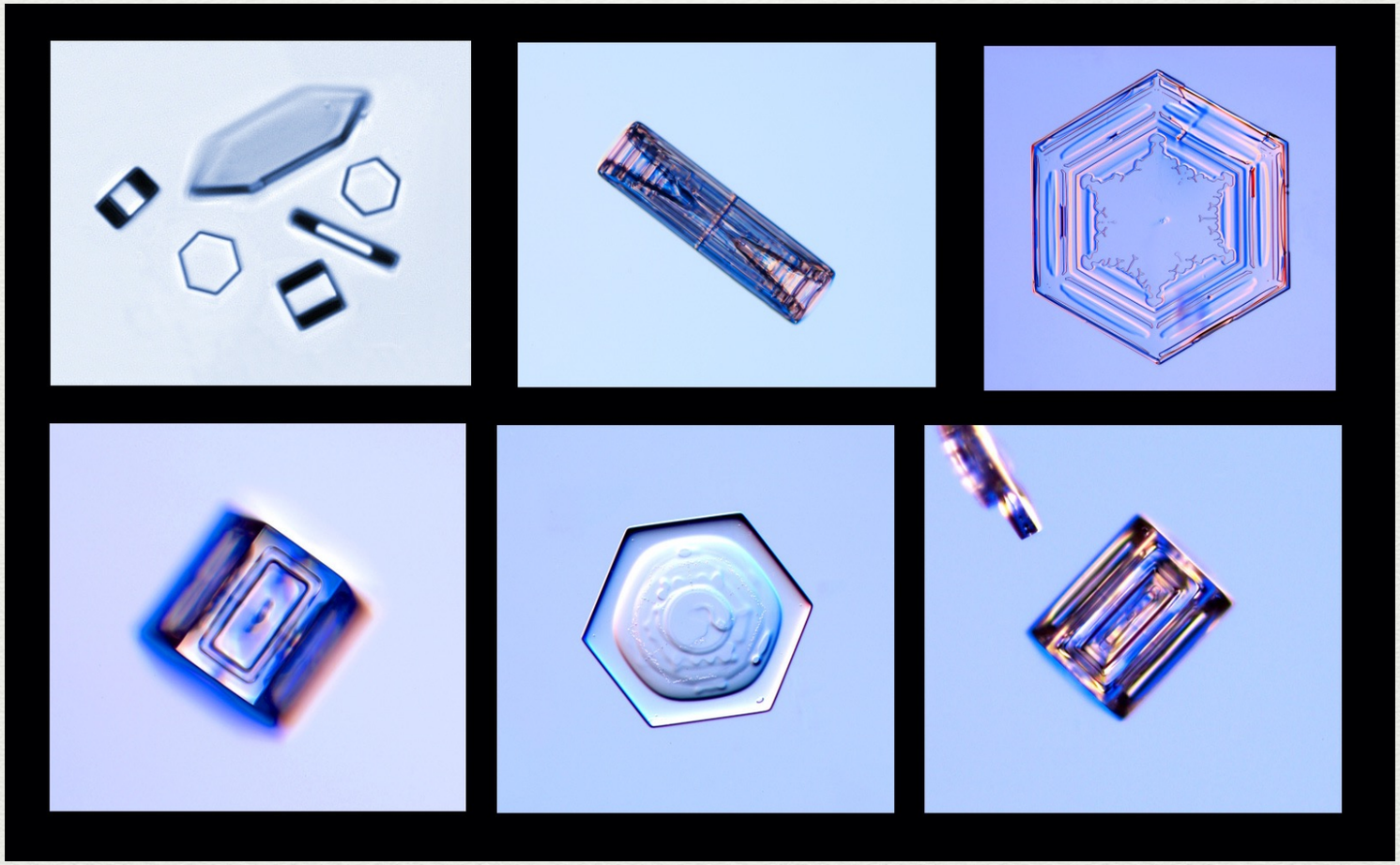
Variation In Temperature

DENDRITIC PLATES TO UNBRANCHED NEEDLE

$$T_{\text{bath}} \approx 4^{\circ}\text{C}$$

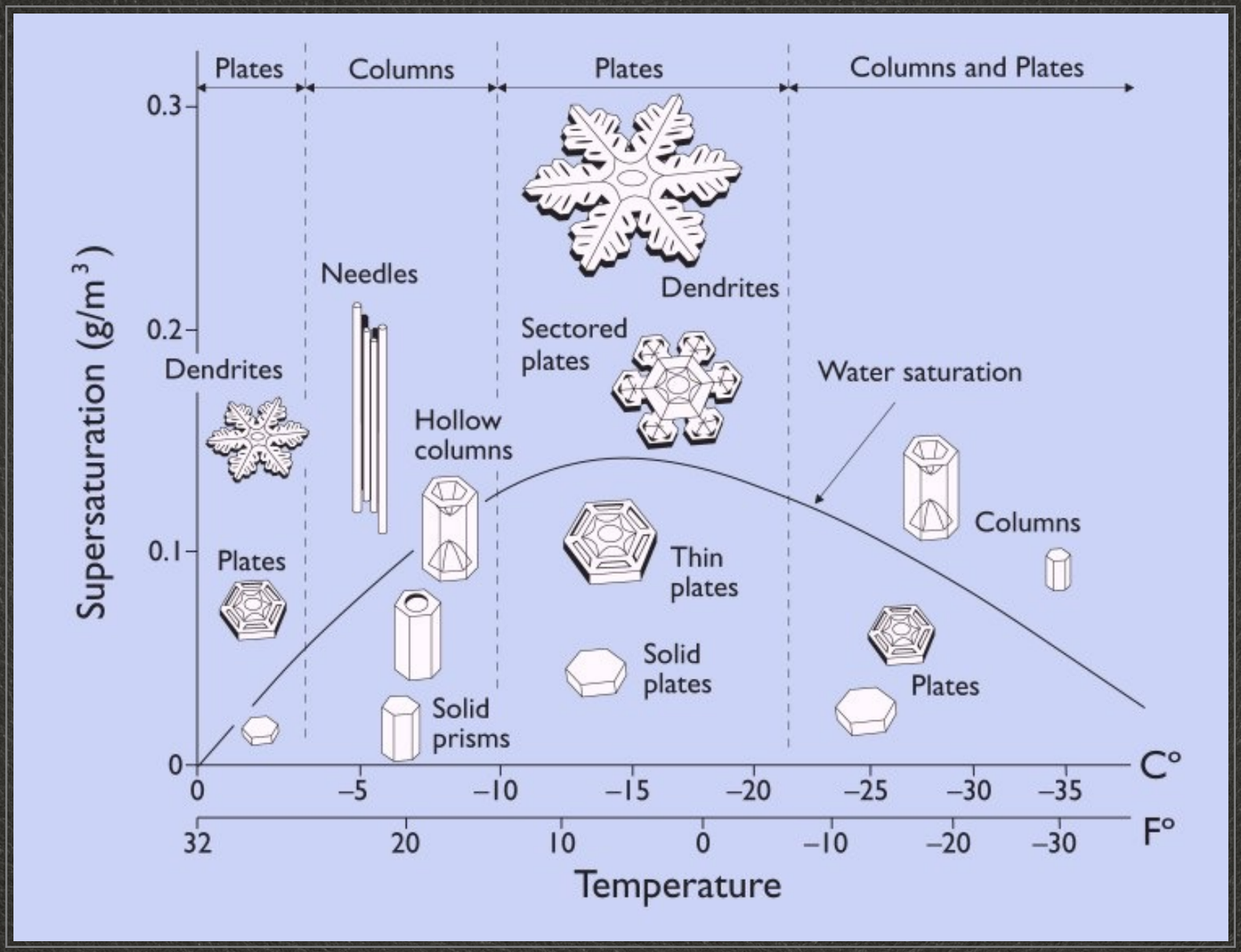
Variation In Temperature

UNBRANCHED NEEDLES TO PLATELETS



ΔT_{bath} is in the range 10 – 30°C

MORPHOLOGY DIAGRAM



Ukichiro Nakaya in the 1930's

APPLICATIONS

PREDICTING AVALANCHES

SIMULATION

THE END