EBB 212/ 3

CHEMICAL SYNTHESIS OF CERAMIC POWDERS (PART 1)

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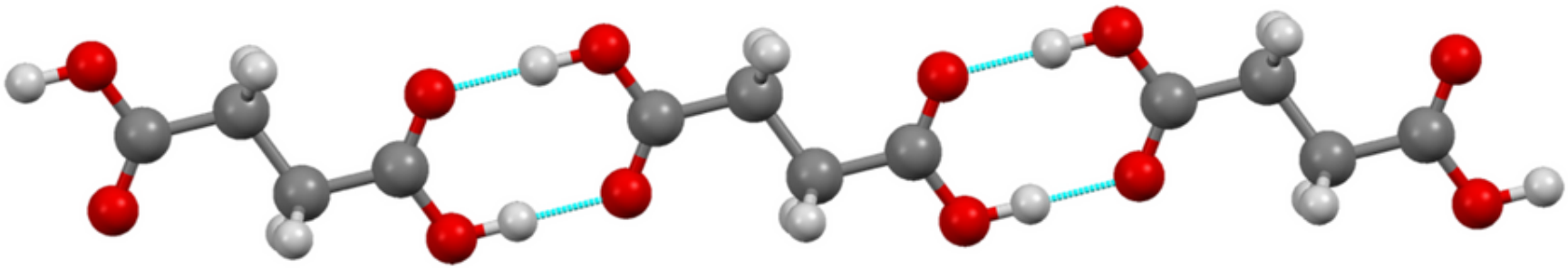
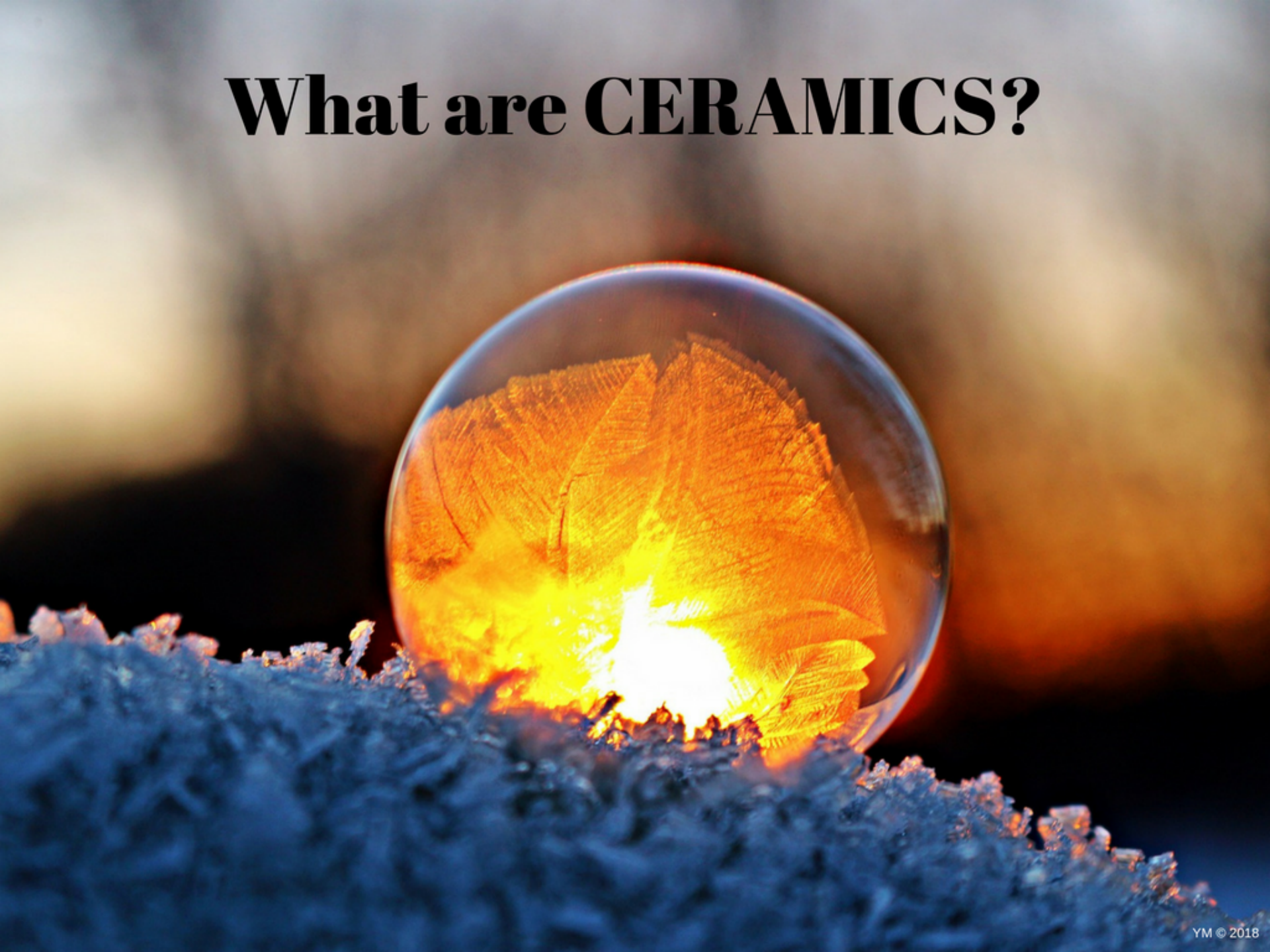
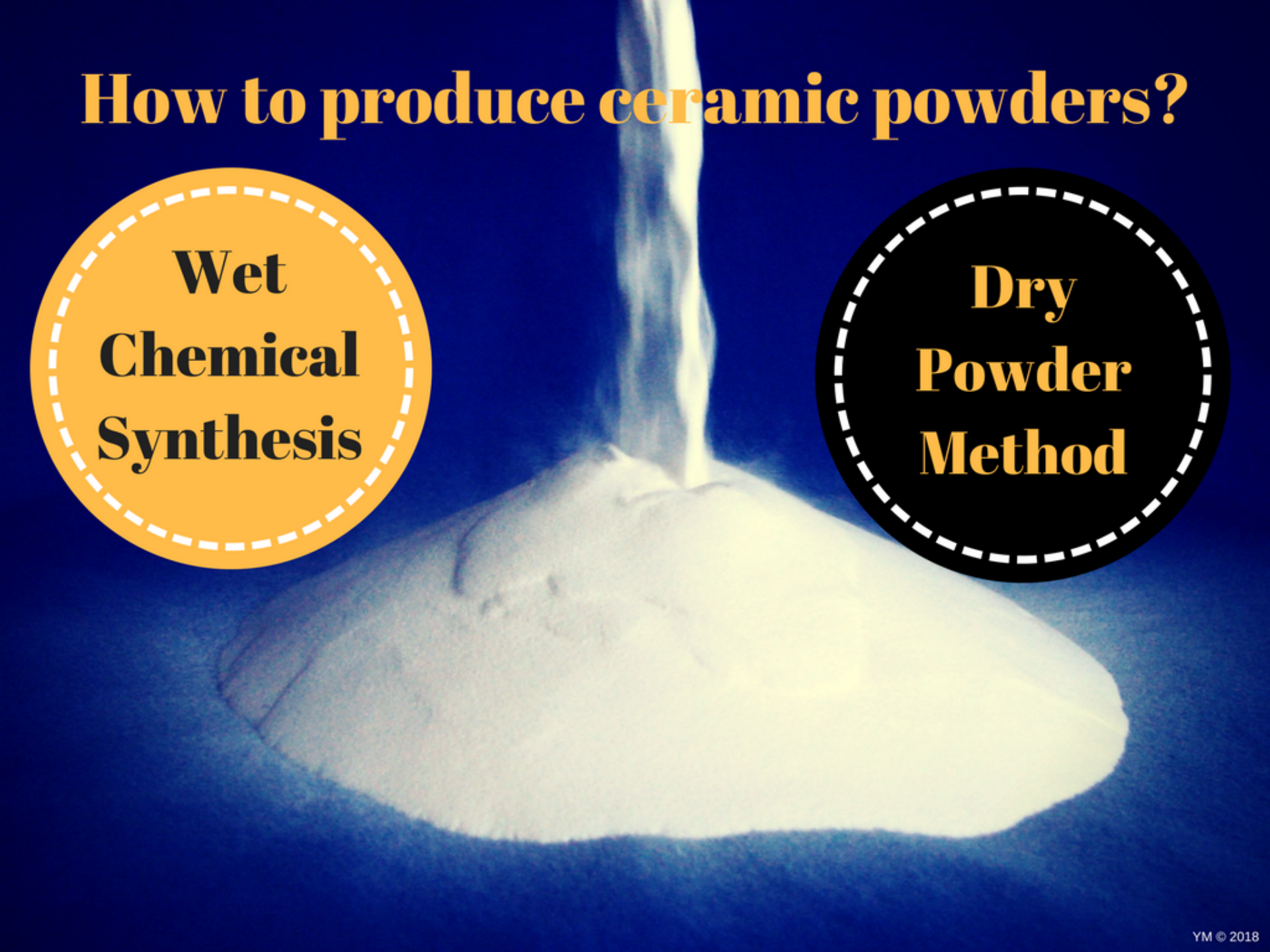


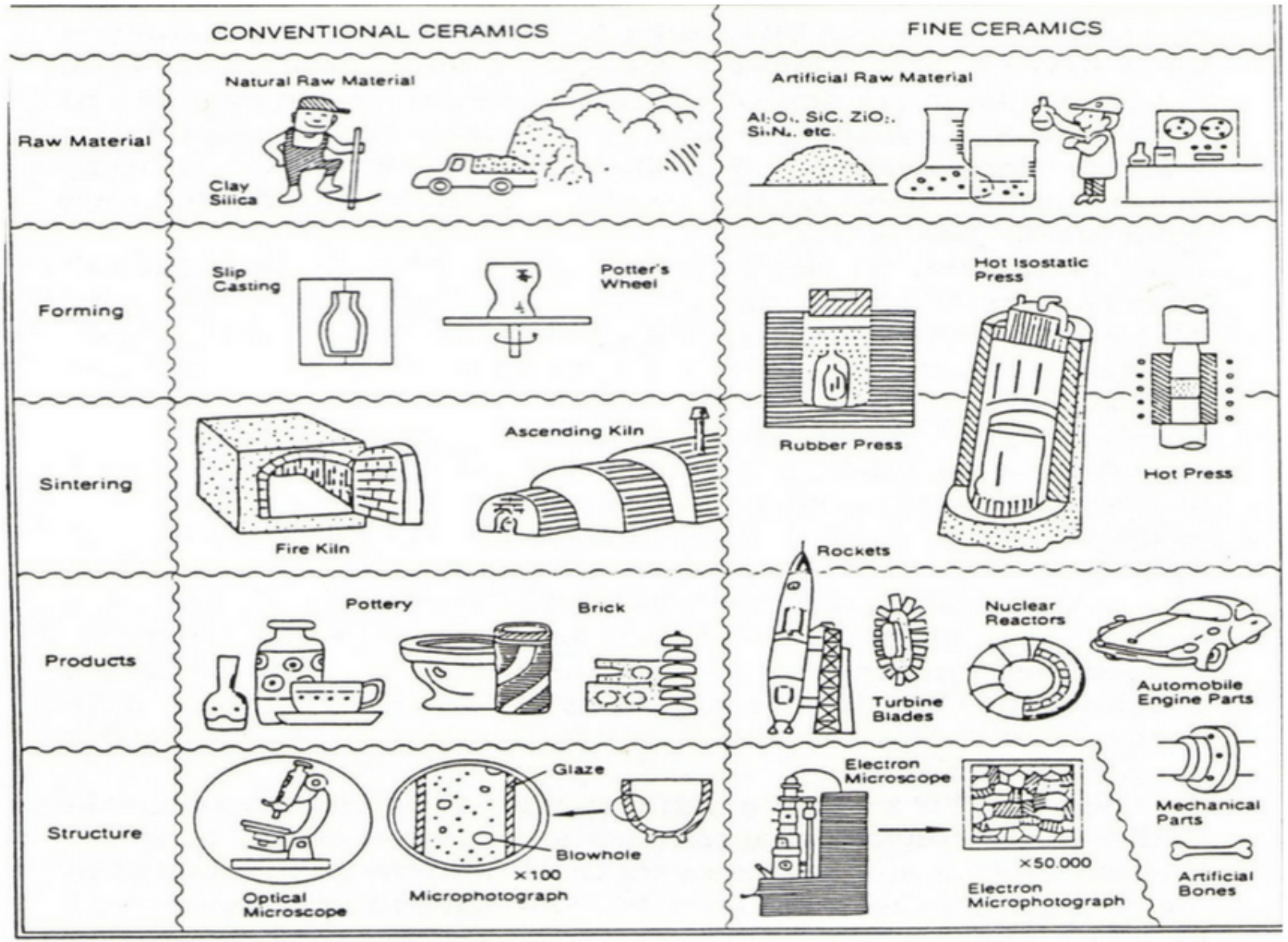
What are CERAMICS?



How to produce ceramic powders?



Conventional vs Fine (Advanced Ceramics)



Conventional vs Fine (Advanced Ceramics)

	Conventional	Advanced
Source of raw materials	Natural	Highly purified natural raw material, artificial (synthetic) & other npon-naturally occuring compounds
Example of raw materials	Clay, feldspar, pottery stones	Alumina, zirconia, ferrite, titania, hydroxyapatite, silicon carbide
Manufacturing	Mixing, shaping	Chemical Synthesis
Sintering	Fire kiln, tunnel kiln	Hot press, HIP
Purity	Low (difficult to avoid contamination)	High (precisely controlled process)
Products	Bricks, pottery	Biomedical, automobiles, semiconductors
Structural Observation	Optical microscope	Electron microscope

Conventional Ceramics:

meet much less specific requirement than advanced ceramics.

Chemically inhomogeneous

Can have complex microstructures

Advanced Ceramics:

must meet very specific properties requirements

chemical composition and microstructures must be well controlled.

What are the important powder characteristics for advanced ceramics?

IMPORTANT

Powder characteristics for advanced ceramics:

- Particle size
- Particle size distribution
- Particle shape
- State of agglomeration
- Chemical composition
- Phase composition

Desired Properties

- Fine
- Narrow
- Spherical/ Equiaxed
- No agglomeration/ Soft agglomeration
- High purity
- Single phase

POWDER PARTICLE SHAPES

SPHERICAL

ROUNDED

ANGULAR

SPONGY

FLAKEY

CYLINDRICAL

ACICULAR

CUBIC

Techniques to produce ceramic powders

Mechanical

Aim

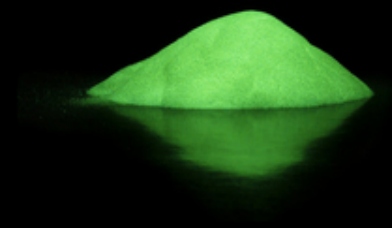
To reduce particles size

Technique

Grinding/milling

Generally used to prepare powder of **conventional ceramics** from naturally occurring raw materials

Recently, has been used in preparation of some advanced ceramics by using high speed plenatary milling



Chemical

Aim

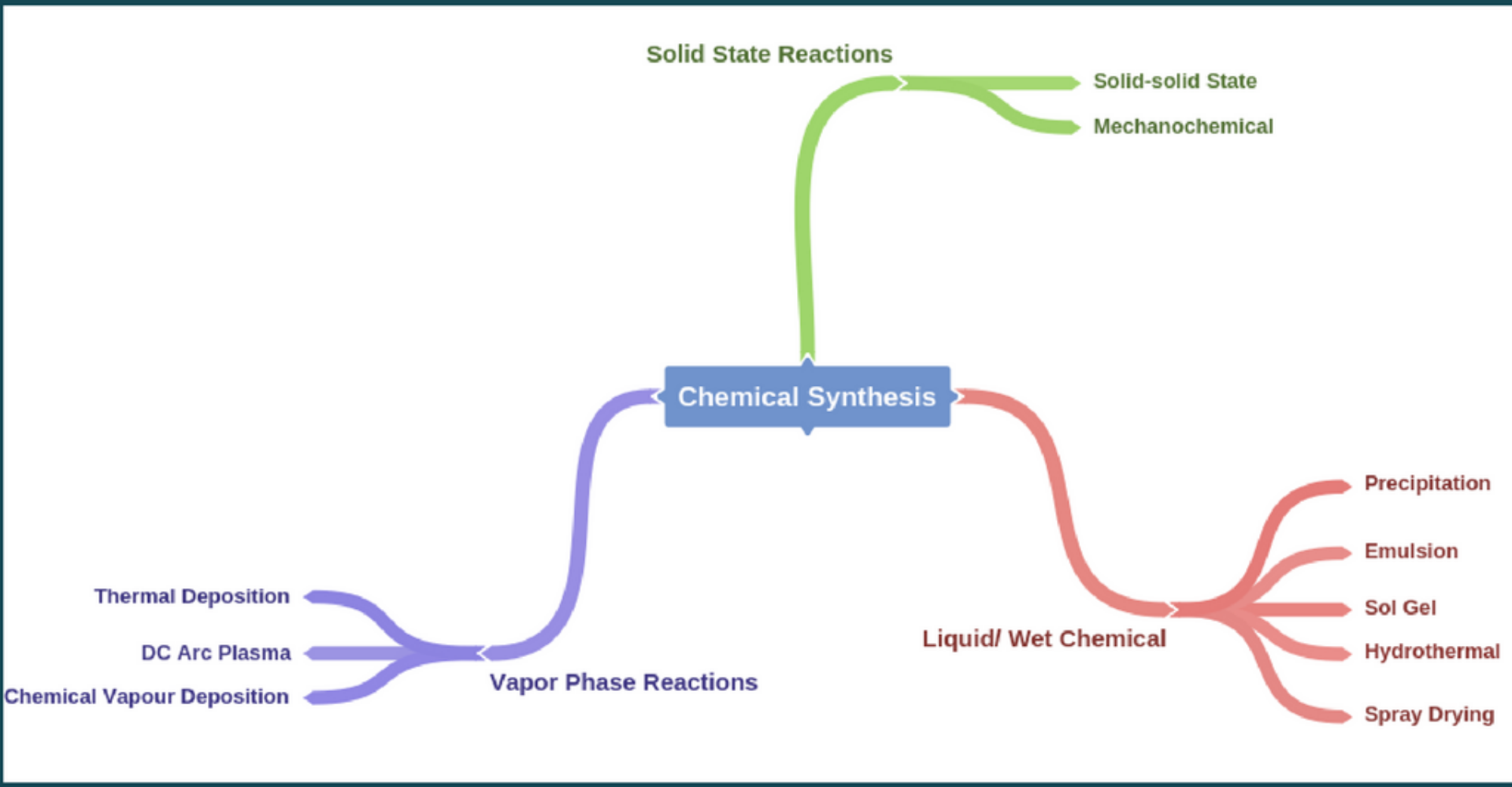
To produce high purity and fine particles size

Technique

Chemical reaction in controlled manner

Generally used to prepare of **advanced ceramics** from synthetic materials

Wide range of chemicals method exist for the preparation of ceramics powder


Solid State Reactions
Solid-solid State
Mechanochemical
Chemical Synthesis
Thermal Deposition
DC Arc Plasma
Chemical Vapour Deposition
Vapor Phase Reactions
Liquid/ Wet Chemical
Precipitation
Emulsion
Sol Gel
Hydrothermal
Spray Drying

Solid State Reaction...

Solid State Reactions

Solid-solid Reaction

Solid-solid Reaction

Chemical decomposition, in which solid reactant is heated to produce new solid.

Solid-solid Reaction

Chemical reaction between **solid starting materials** (usually in the form of mixed powder).

Commonly used for production of complex oxide.

Example

Decomposition of magnesium carbonate to produce magnesium oxide:

Example

Reaction between barium carbonate and titania to produce barium titanate

Example

Reaction between barium carbonate and titania to produce barium titanate

$$BaCO_3\,(s) + TiO_2\,(s) \dashrightarrow BaTiO_3(s) + CO_2(g)$$

Decomposition of solids or chemical reaction between solids, which take place above thermal decomposition T

calcination

Advantages versus Disadvantages

Easy production method

Availability of wide range of solid reactants

Formation of undesirable phases

Large grain size- can be detrimental for high-strength ceramic components due to firing at high T and poor chemical homogeneity particularly when dopant oxides are introduced

Particle size reduction by milling can introduced chemical impurities into the ceramic products

Mechanochemical Method

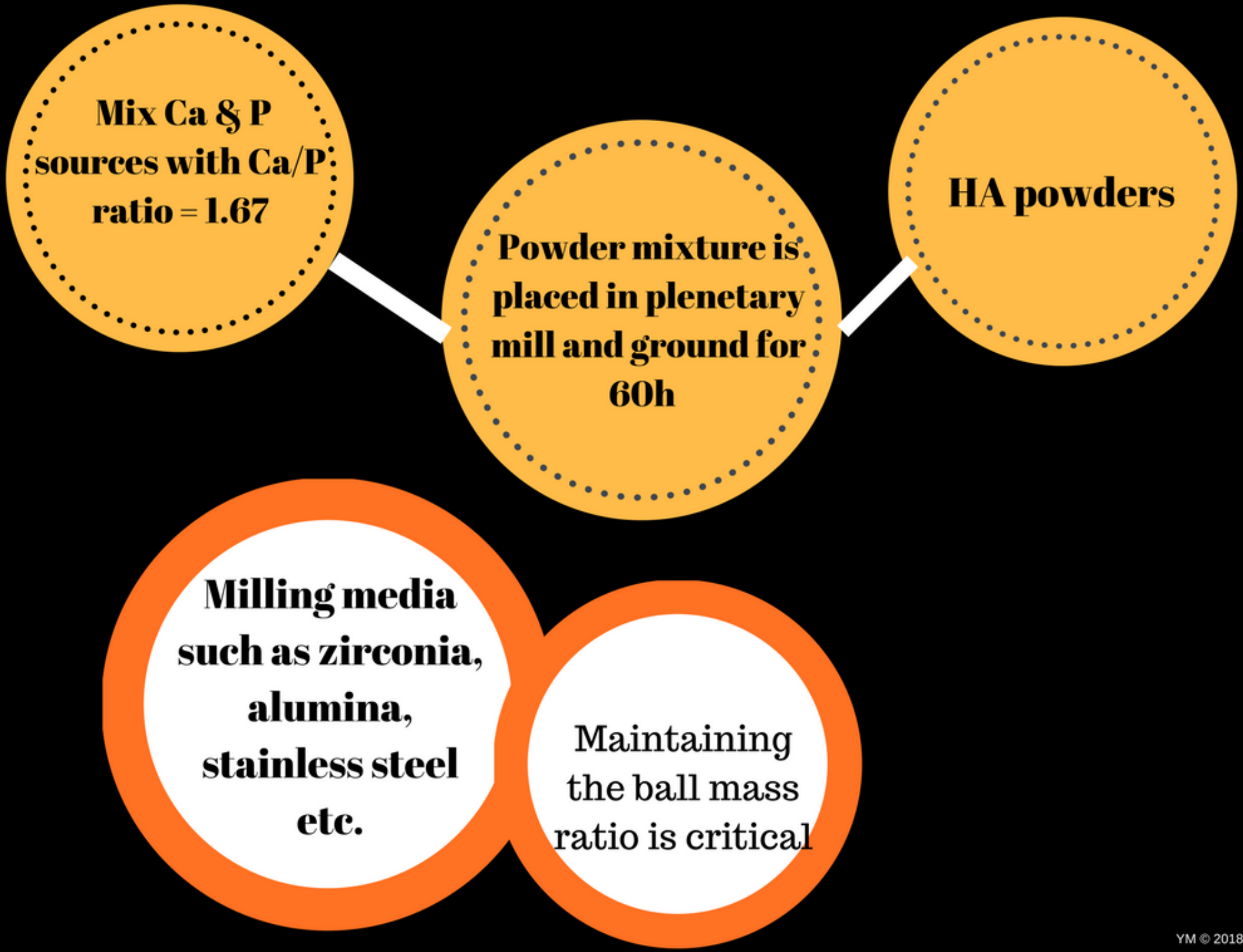
By definition...

Chemical reaction between **solid starting materials** (usually in the form of mixed powder) and are common for production of complex oxide.

Sometimes known as **mechanical alloying**

Working Principle:

The **mechanical force (high energy collision)** from the balls is used to **achieve chemical processing** and **phase transformation**.


Mix Ca & P sources with Ca/P ratio = 1.67
Powder mixture is placed in plenetary mill and ground for 60h
HA powders
Milling media such as zirconia, alumina, stainless steel etc.
Maintaining the ball mass ratio is critical

Low production cost

Agglomerate: Grinding required- leads to potential contamination

Availability of raw materials

Incomplete Reaction

What is the alternative method?

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The clear way to share complex information.

STEP 3