Anaerobic digestion and some potential uses of biogas

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HD
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Anaerobic Digestion:

CH_4

CO_2

Volatile Acid/Alkalinity Ratio

H_2S

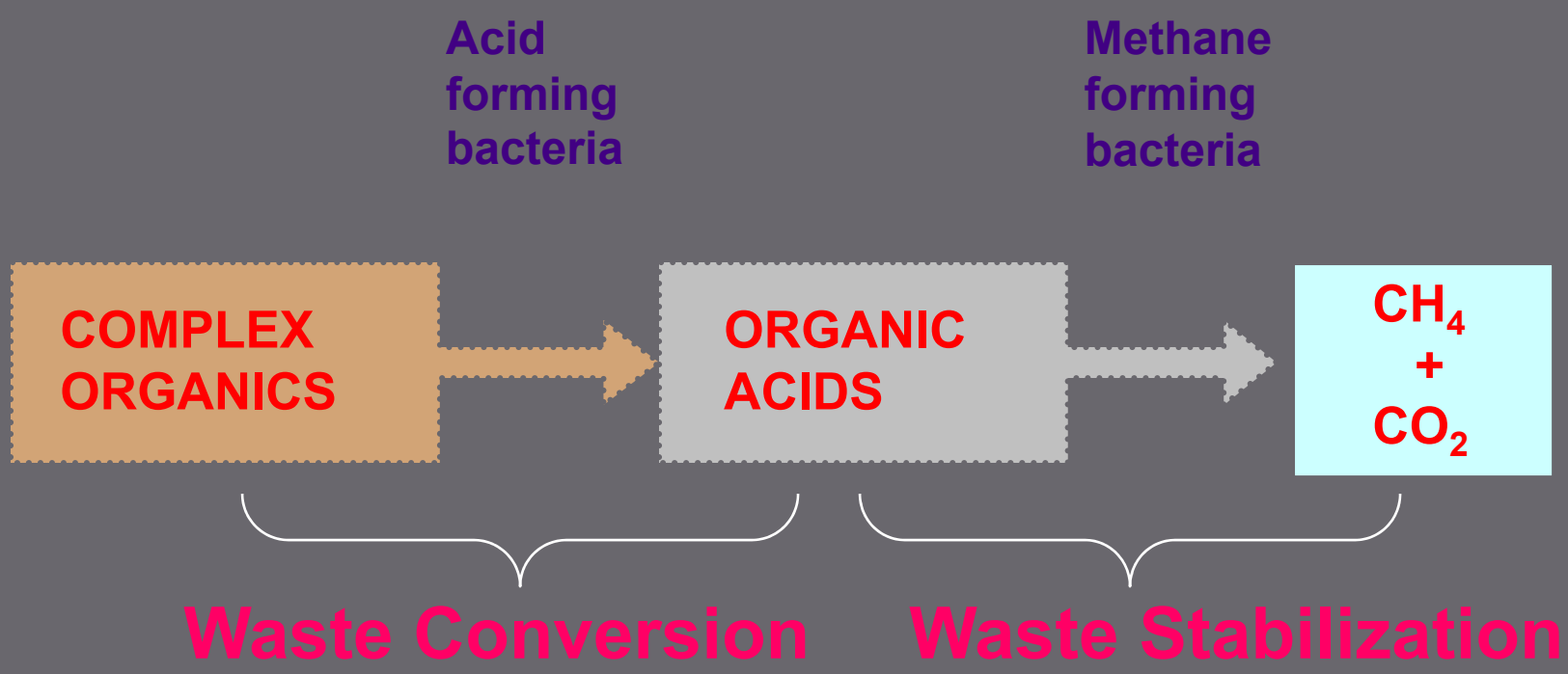
pH range

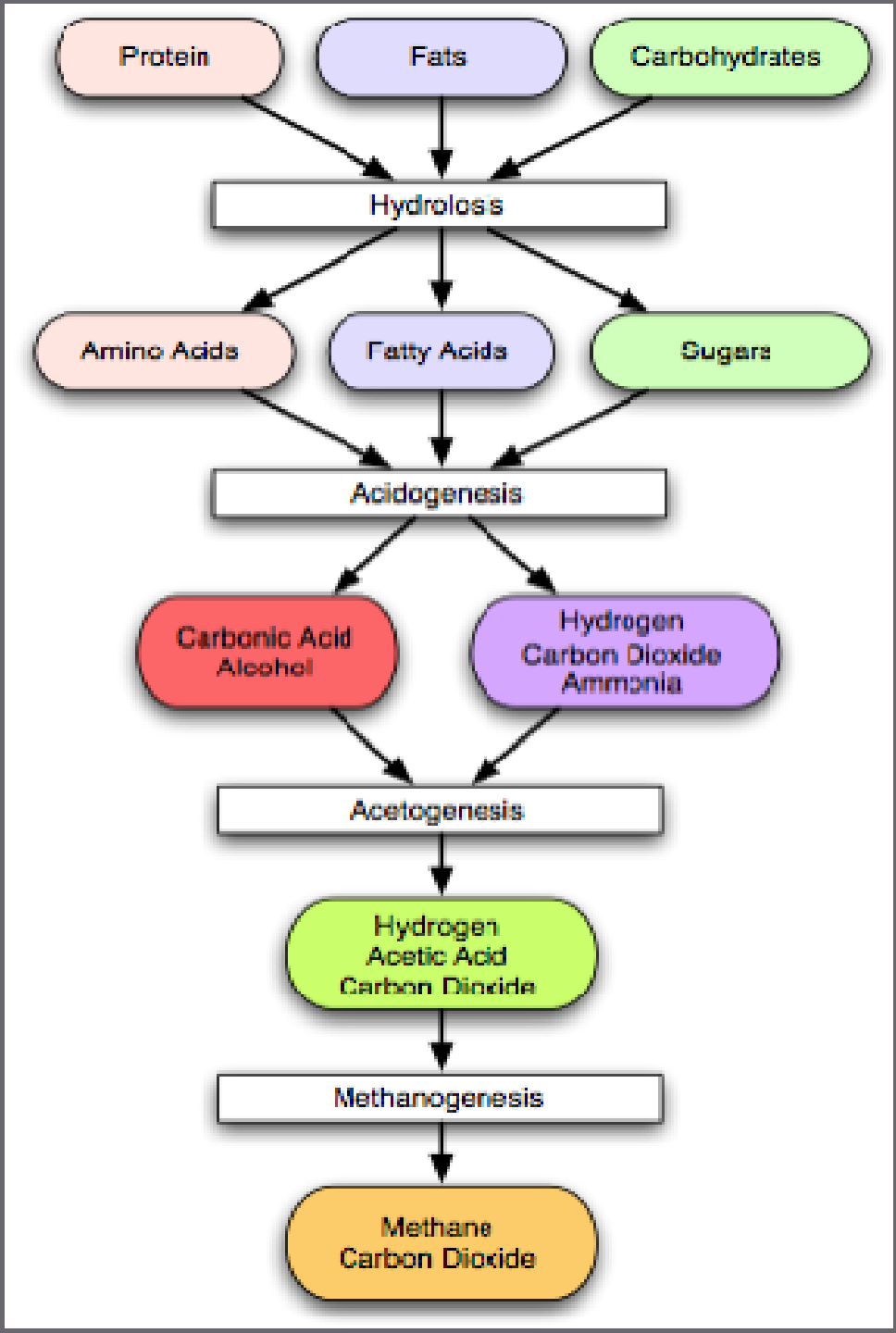
Temperatures

N_2

H_2

Kinetics of Sludge Digestion




Protein
Fats
Carbohydrates
Hydrolosis
Amino Acids
Fatty Acids
Sugars
Acidogenesis
Carbonic Acid
Alcohol
Hydrogen
Carbon Dioxide
Ammonia
Acetogenesis
Hydrogen
Acetic Acid
Carbon Dioxide
Methanogenesis
Methane
Carbon Dioxide

Reactions In The Digester

Acid Fermentation

RAW sludge + **Acid Formers** → **CO_2 + H_2O + Organic Acids**

(carbohydrates fats, and protein) (Saprophytic facultative bacteria) (intermediate degradation products) (cellular & intermediate products)

Methane Formation

Organic acids + **Methane Formers** → **CH_4 + CO_2 + other products**

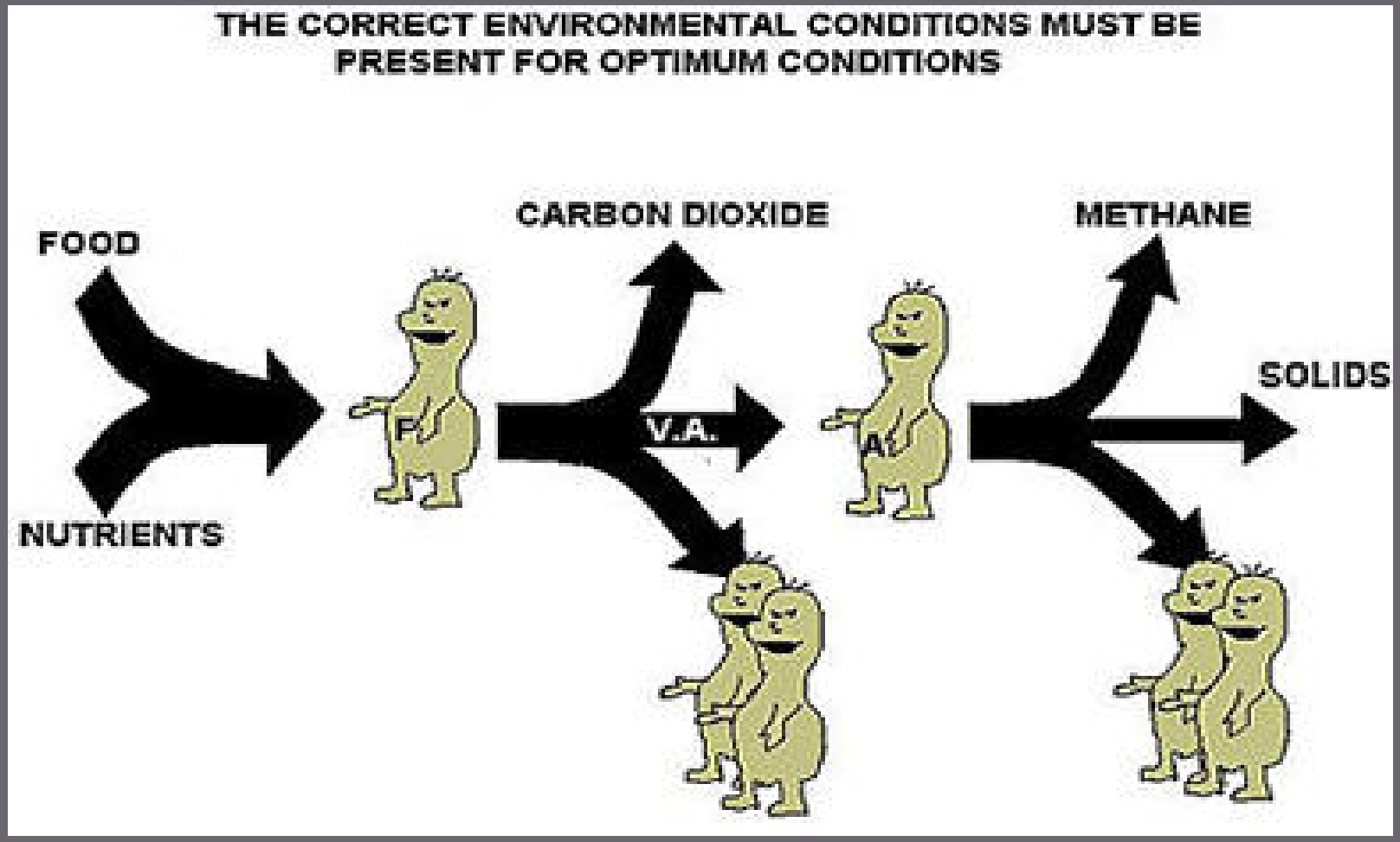
(cellular and other intermediate products) (obligate anaerobes) **(H_2O, H_2S)**

65-70% **CH_4 and** 25-30% **CO_2**

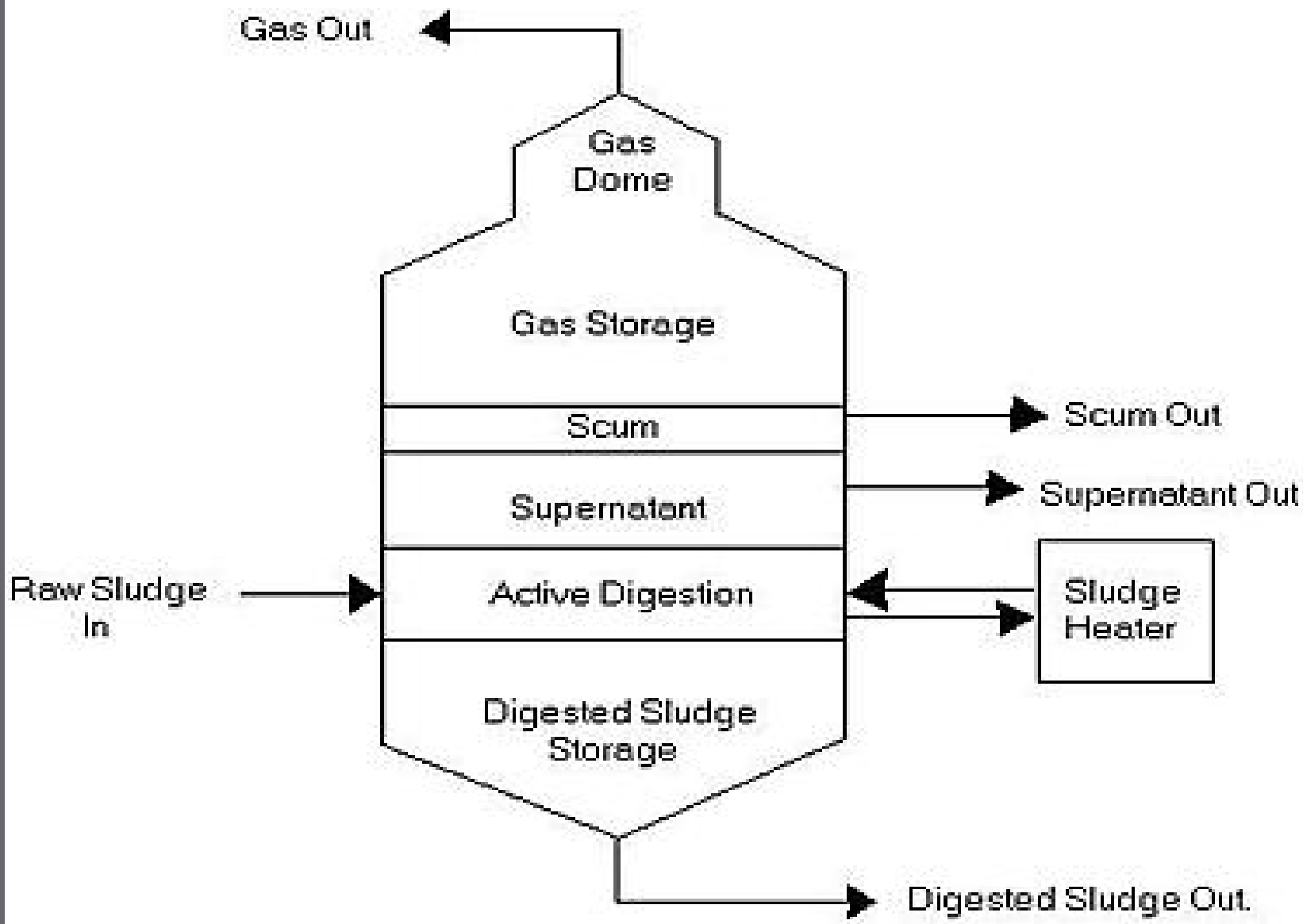
Typical composition of biogas

Compound	Chemical	%
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulfide	H_2S	0–3
Oxygen	O_0	0–0

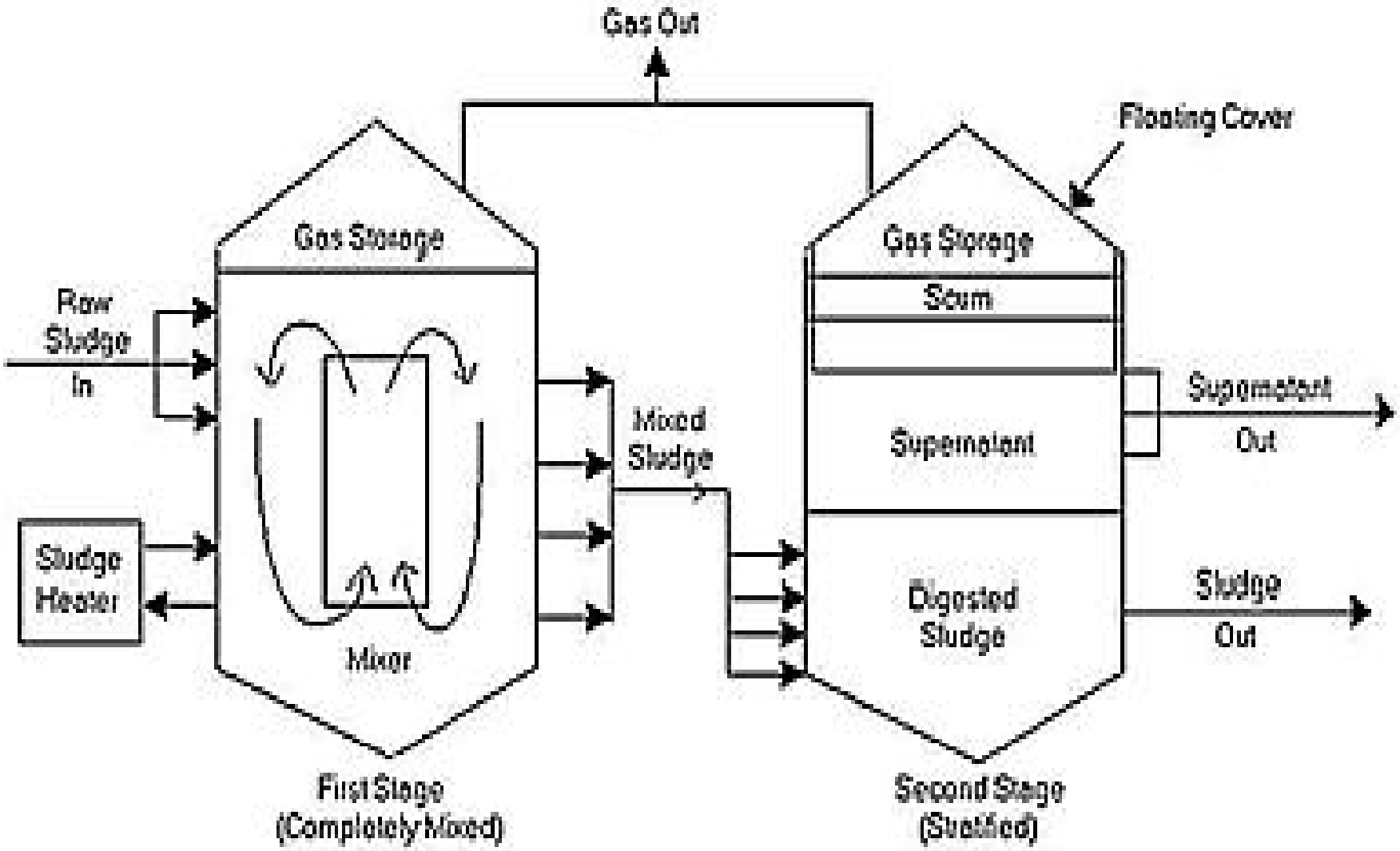
Path of Anaerobic Digestion



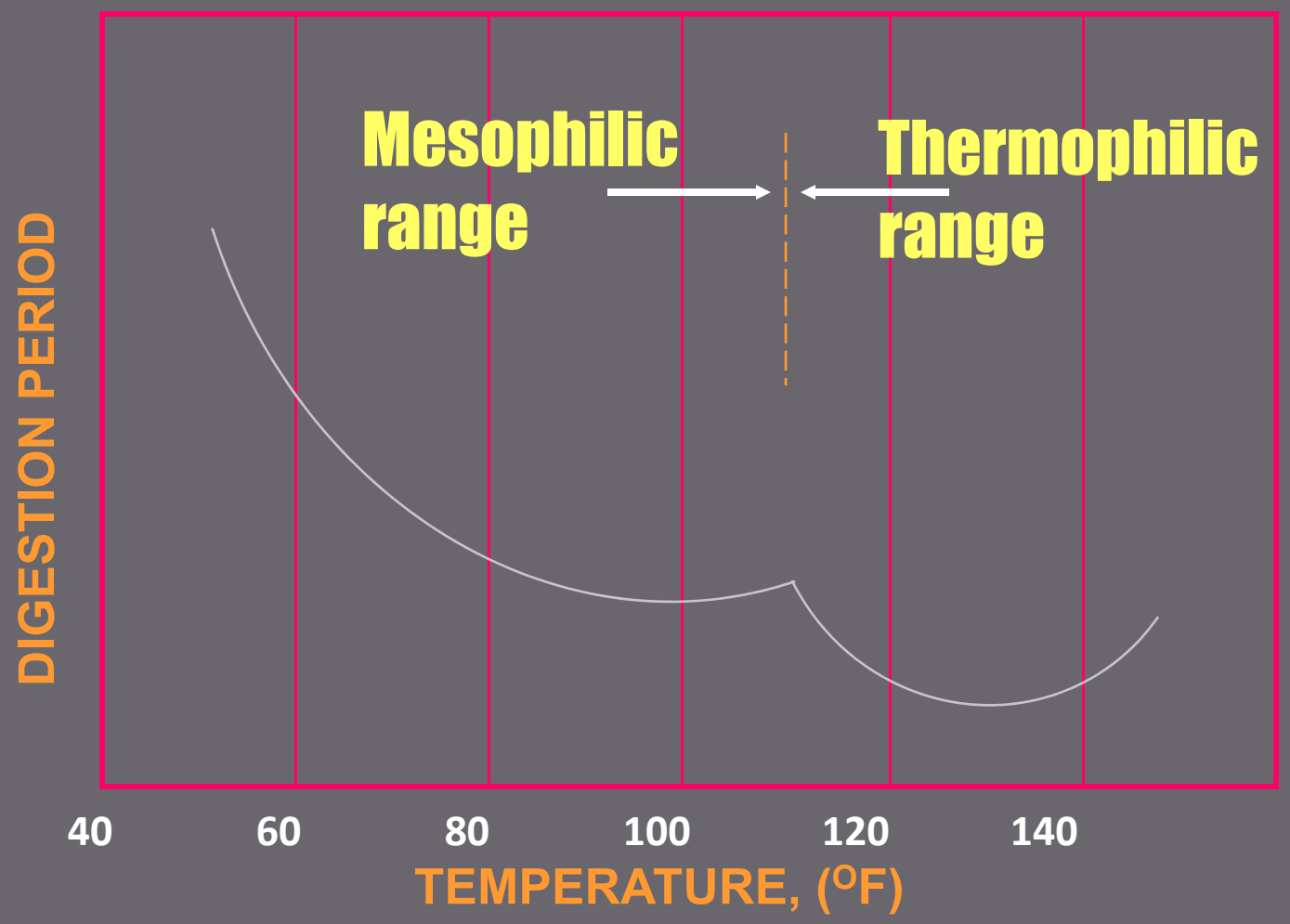
Single Stage, Standard Rate Anaerobic Digester



Two Stage, High Rate Anaerobic Digester



Temperature Ranges Versus Digestion Time.



Filling of Digester @ Start-up

- Add water or raw wastewater.
- Bring up to temperature and begin mixing.
- Then add raw sludge.

WARNING!

Gas build-up and explosion (i.e. methane)

Explosive range of *methane* is?

Design Criteria For Standard Rate and High Rate Digesters

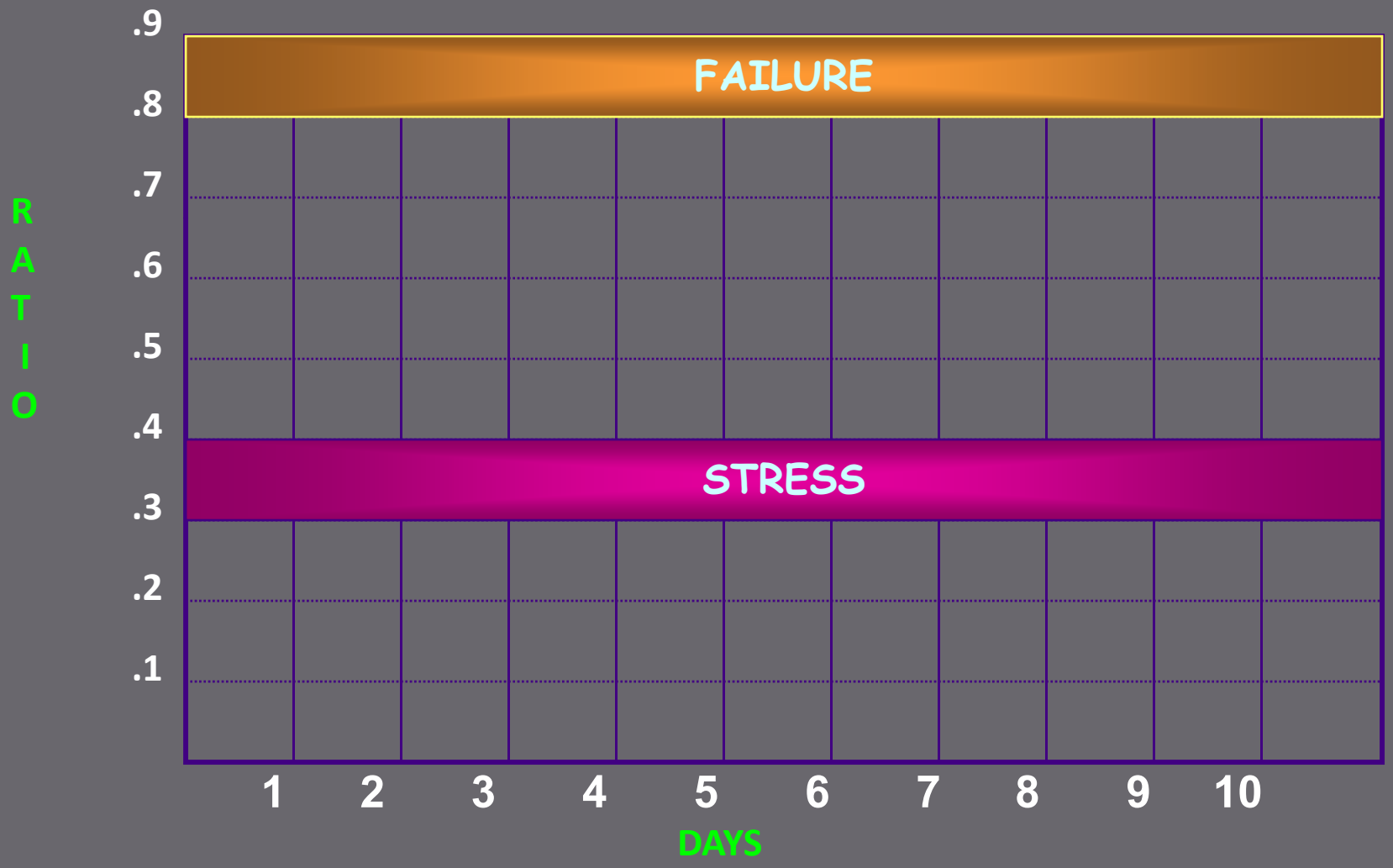
Parameter	Low Rate	High Rate
Solids Retention Time (SRT), in days	30 to 60	10 to 20
Solids Loading, lbs. VSS/cu ft/day	0.04 to 0.1	0.15 to 0.40
Volume Criteria, cu ft/capita		
Primary Sludge	2 to 3	1-1/3 to 2
Primary Sludge + Trickling Filter Sludge	4 to 5	2-2/3 to 3-1/3
Primary Sludge + Waste Activated Sludge	4 to 6	2-2/3 to 4

Physical and Chemical Factors

Physical Factors	Chemical Factors
• Detention Time	• pH
• Temperature	• Alkalinity
• Solids Concentration	• Volatile Acid Content
• Degree of Mixing	• Nutrients
• Solids Loading & Distribution	• Toxic Materials

Volatile Acids/Total Alkalinity

Trend Chart



Potential energy uses

- Electrical energy production
- Steam production
- Combined heat and power production, CHP

COMBINED HEAT & POWER PLANT

(CHP)