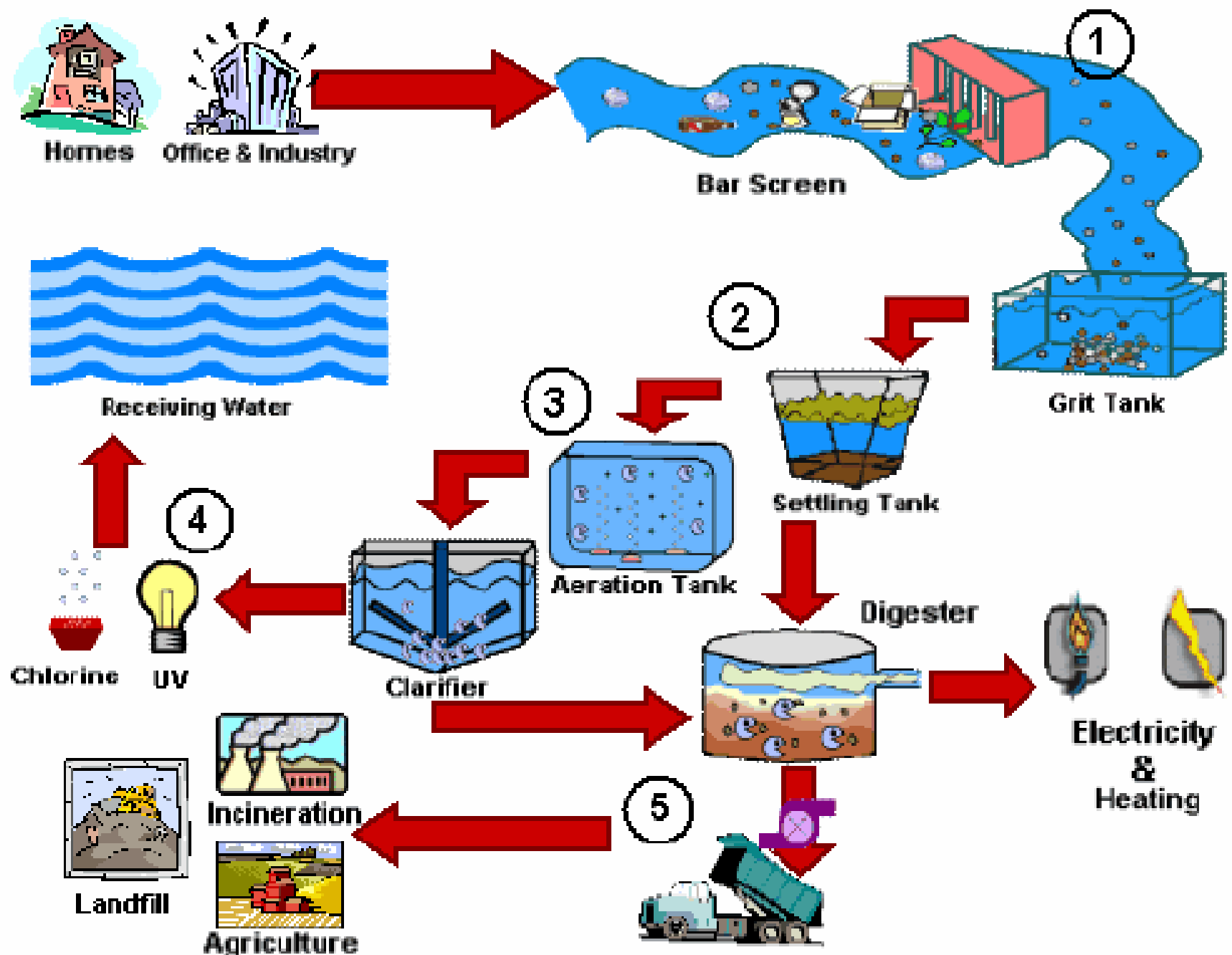
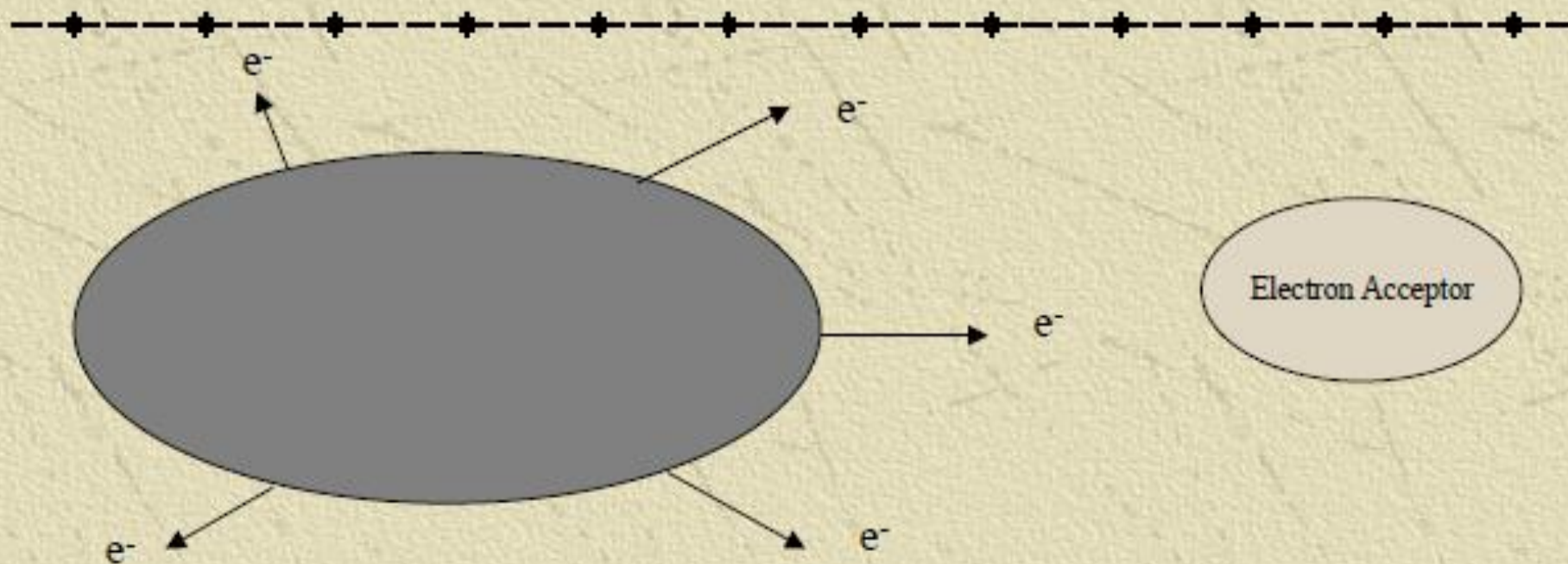


HOW IT WORKS

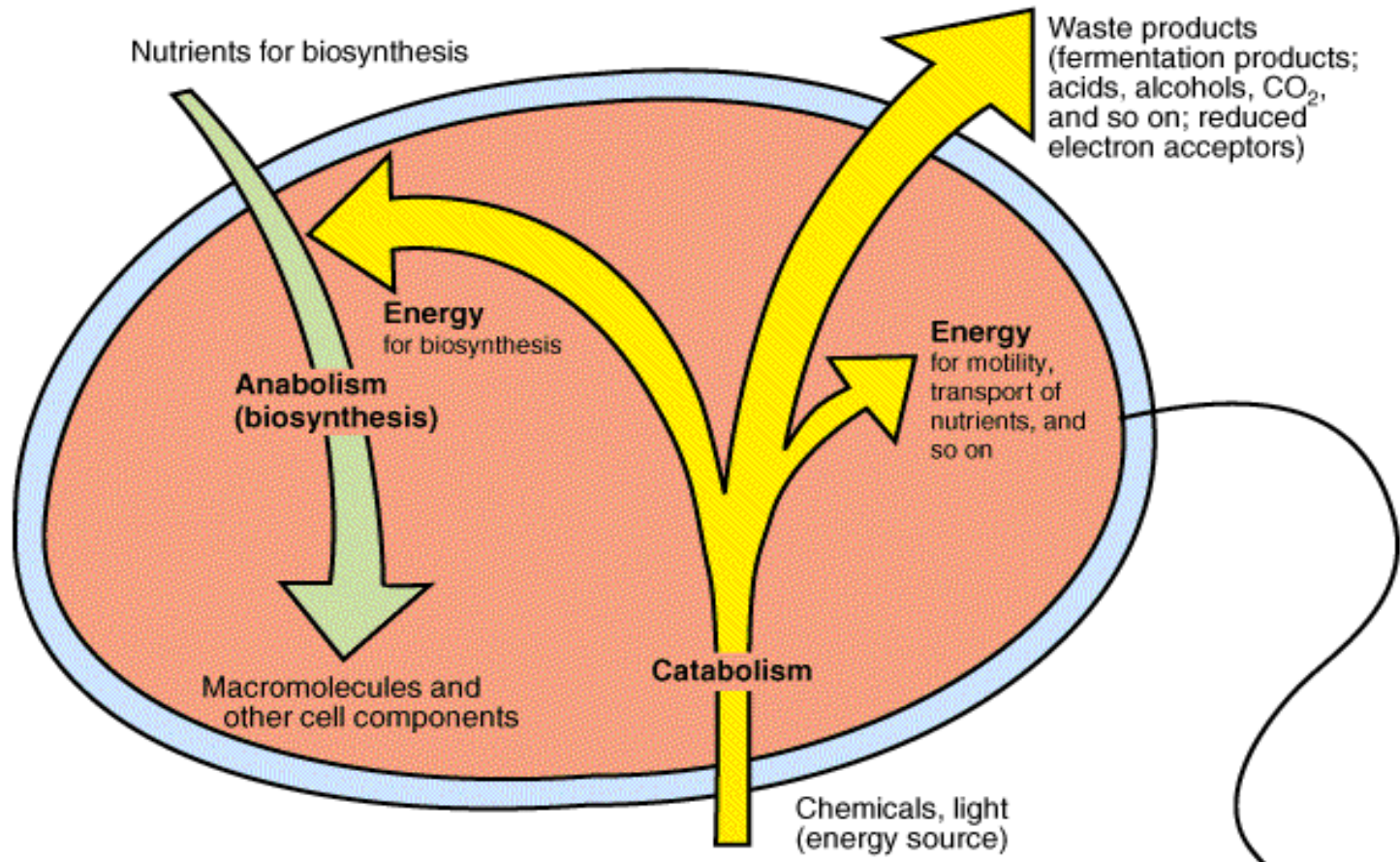


Oxidation of Organic Compounds

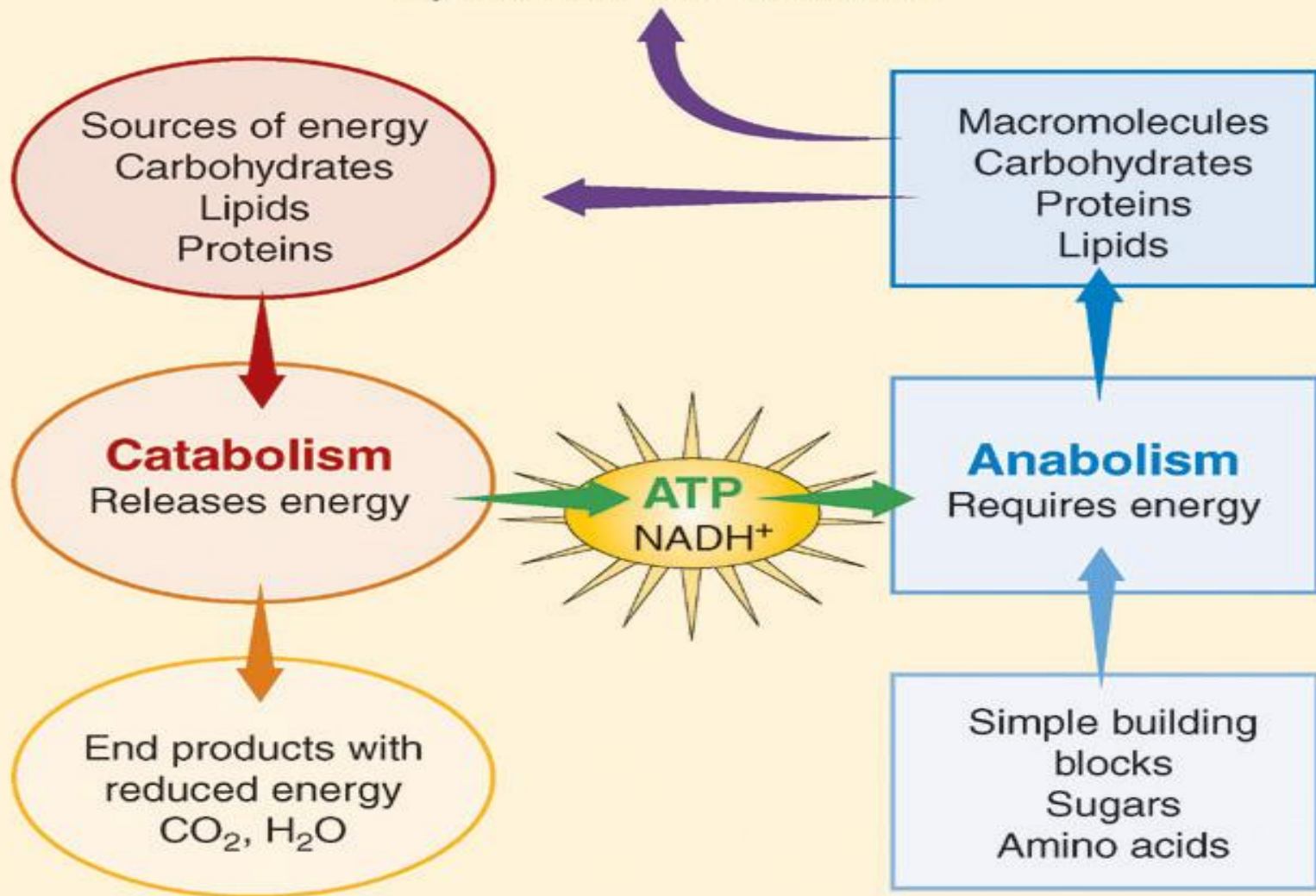


- ♦ Oxidation is loss of electrons
- ♦ Organics are oxidized
- ♦ Electron acceptor is reduced

Overview of cell metabolism

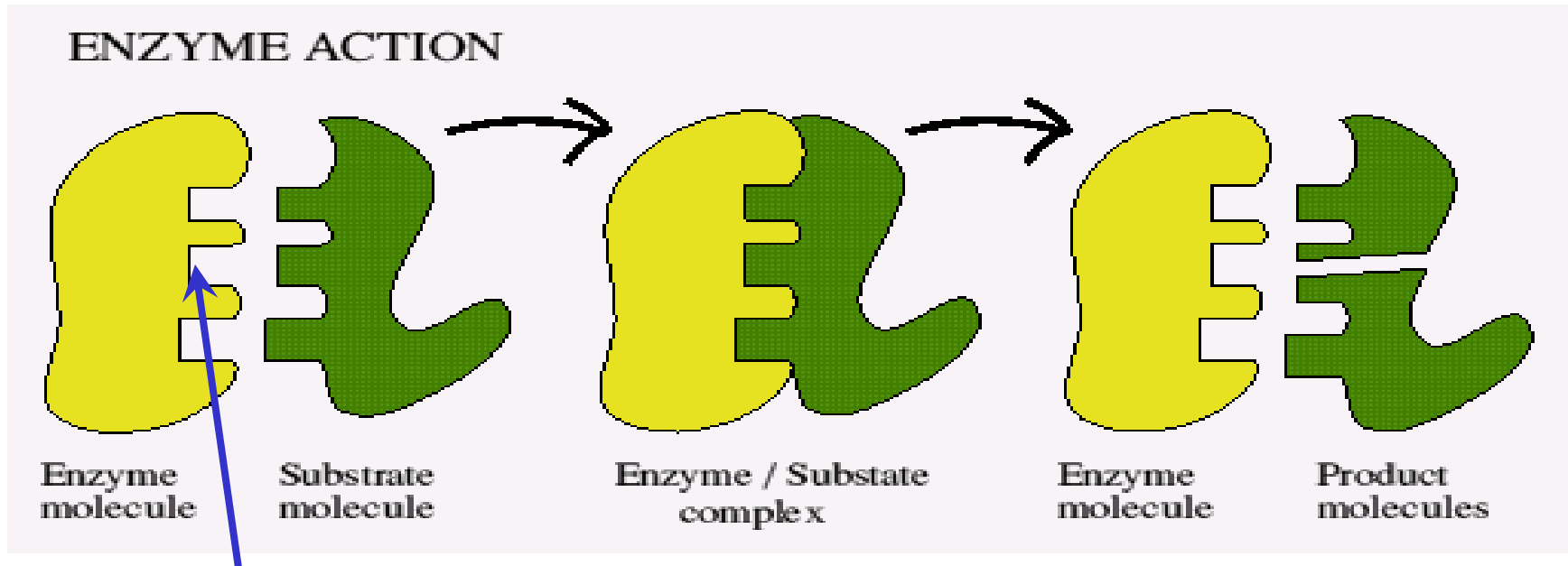


Synthesis of Cell Structures



Enzyme structure

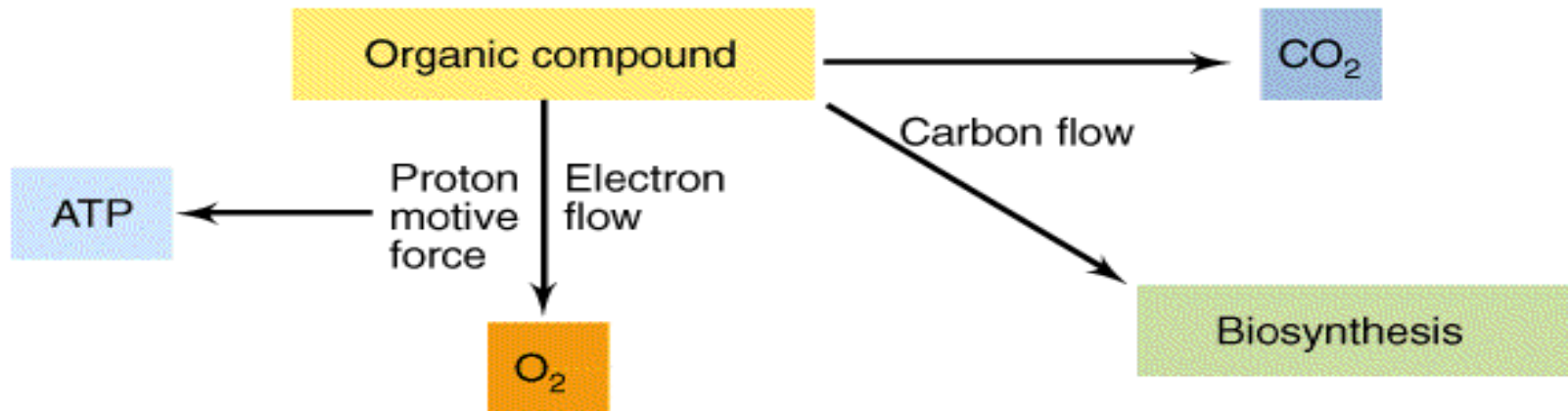
- simple enzymes → consist of protein alone



active site = the site that accepts a substrate

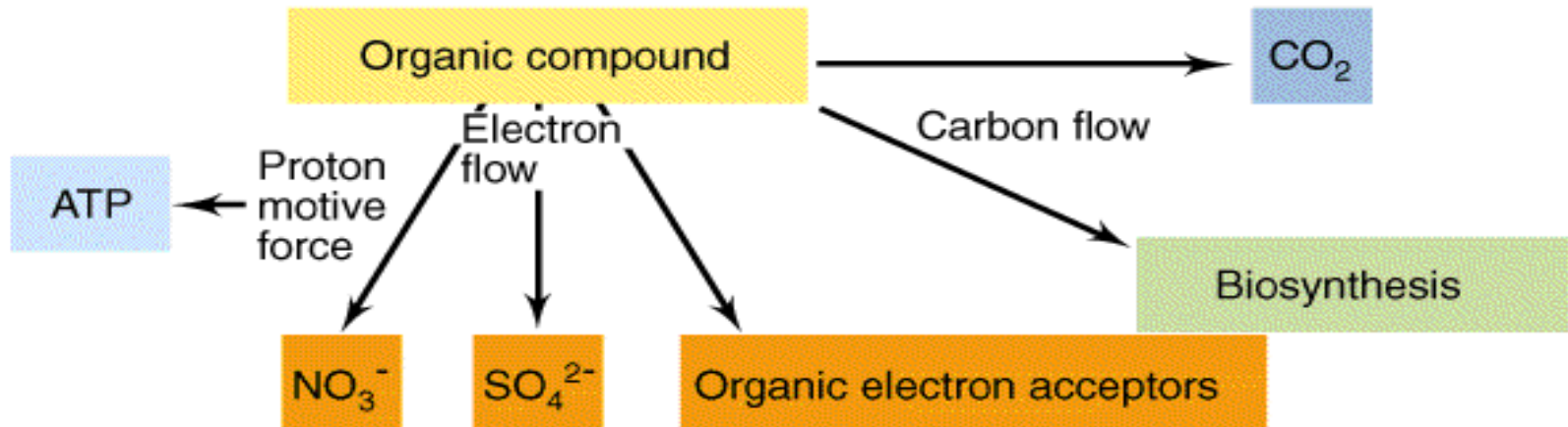
Alternative energy generating patterns⁽¹⁾

Aerobic respiration



Alternative energy generating patterns⁽²⁾

Anaerobic respiration



Alternative energy generating patterns⁽³⁾

Chemolithotrophic metabolism

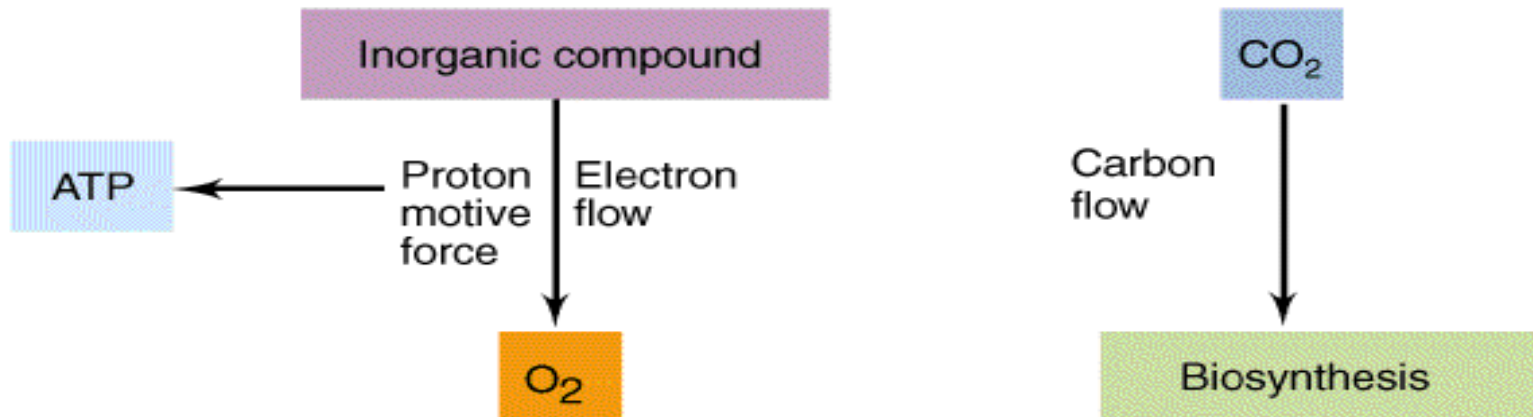


Table 2.3 Trophic classification of microorganisms (adapted from Rittmann and McCarty, 2001; Metcalf & Eddy, 2003)

		Energy source		Carbon source ¹	
		Electron donor	Electron acceptor	Typical products ²	
Trophic group	Microbial group	Type of e ⁻ donor			
Chemotroph					
Organotroph	Aerobic heterotrophs	Organic	O ₂	CO ₂ , H ₂ O	Organic
	Denitrifiers	Organic	NO ₃ ⁻ , NO ₂ ⁻	N ₂ , CO ₂ , H ₂ O	Organic
	Fermenting organisms	Organic	Organic	Organic VFAs ³	Organic
	Iron reducers	Organic	Fe (III)	Fe (II)	Organic
	Sulfate reducers	Acetate	SO ₄ ²⁻	H ₂ S	Acetate
	Methanogens (acetoclastic)	Acetate	acetate	CH ₄	Acetate
Lithotroph	Nitrifiers: AOB ⁴	NH ₄ ⁺	O ₂	NO ₂ ⁻	CO ₂
	Nitrifiers: NOB ⁵	NO ₂ ⁻	O ₂	NO ₃ ⁻	CO ₂
	Anammox ⁶ bacteria	NH ₄ ⁺	NO ₂ ⁻	N ₂	CO ₂
	Denitrifiers	H ₂	NO ₃ ⁻ , NO ₂ ⁻	N ₂ , H ₂ O	CO ₂
	Denitrifiers	S	NO ₃ ⁻ , NO ₂ ⁻	N ₂ , SO ₄ ²⁻ , H ₂ O	CO ₂
	Iron oxidizers	Fe (II)	O ₂	Fe (III)	CO ₂
	Sulphate reducers	H ₂	SO ₄ ²⁻	H ₂ S, H ₂ O	CO ₂
	Sulphate oxidizers	H ₂ S, S ⁰ , S ₂ O ₃ ²⁻	O ₂	SO ₄ ²⁻	CO ₂
	Aerobic hydrogenotrophs	H ₂	O ₂	H ₂ O	CO ₂
	Methanogens (hydrogenotrophic)	H ₂	CO ₂	CH ₄	CO ₂
Phototroph					
	Algae, plants	H ₂ O	CO ₂	O ₂	CO ₂
	Photosynthetic bacteria	H ₂ S	CO ₂	S (0)	CO ₂

¹ Carbon source: organic for heterotrophs and inorganic (CO₂) for autotrophs; mixotrophs can use both. ² Typical products: CO₂ and H₂O are products of catalysis (energy generation) by many micro-organisms. ³ VFAs: volatile fatty acids (typically acetate, propionate, butyrate).

⁴ AOB: ammonia oxidizing bacteria. ⁵ NOB: nitrite oxidizing bacteria. ⁶ Anammox: anaerobic ammonia oxidizing bacteria.

Table 3.1 Wastewater types

Wastewater from society	Wastewater generated internally in treatment plants
Domestic wastewater	Thickener supernatant
Wastewater from institutions	Digester supernatant
Industrial wastewater	Reject water from sludge dewatering
Infiltration into sewers	Drainage water from sludge drying beds
Stormwater	Filter wash water
Leachate	Equipment cleaning water
Septic tank wastewater	

Table 3.2 Constituents present in domestic wastewater (based on Henze *et al.*, 2001)

Wastewater constituents		
Microorganisms	Pathogenic bacteria, virus and worms eggs	Risk when bathing and eating shellfish
Biodegradable organic materials	Oxygen depletion in rivers, lakes and fjords	Fish death, odours
Other organic materials	Detergents, pesticides, fat, oil and grease, colouring, solvents, phenols, cyanide	Toxic effect, aesthetic inconveniences, bio accumulation in the food chain
Nutrients	Nitrogen, phosphorus, ammonium	Eutrophication, oxygen depletion, toxic effect
Metals	Hg, Pb, Cd, Cr, Cu, Ni	Toxic effect, bioaccumulation
Other inorganic materials	Acids, for example hydrogen sulphide, bases	Corrosion, toxic effect
Thermal effects	Hot water	Changing living conditions for flora and fauna
Odour (and taste)	Hydrogen sulphide	Aesthetic inconveniences, toxic effect
Radioactivity		Toxic effect, accumulation

Table 3.4 Variations in person load (Henze et al., 2001)

Parameter	Unit	Range
COD	g/cap.d	25-200
BOD	g/cap.d	15-80
Nitrogen	g/cap.d	2-15
Phosphorus	g/cap.d	1-3
Wastewater	m ³ /cap.d	0.05-0.40

Table 3.5. Person load in various countries in kg/cap.yr (based on Henze et al., 2002)

Parameter	Brazil	Egypt	India	Turkey	US	Denmark	Germany
BOD	20-25	10-15	10-15	10-15	30-35	20-25	20-25
TSS	20-25	15-25		15-25	30-35	30-35	30-35
N total	3-5	3-5		3-5	5-7	5-7	4-6
P total	0.5-1	0.4-0.6		0.4-0.6	0.8-1.2	0.8-1.2	0.7-1

Table 3.7 Typical content of nutrients in raw municipal wastewater with minor contributions of industrial wastewater (in g/m³)

Parameter	High	Medium	Low
N total	100	60	30
Ammonia N	75	45	20
Nitrate + Nitrite N	0.5	0.2	0.1
Organic N	25	10	15
Total Kjeldahl N	100	60	30
P total	25	15	6
Ortho-P	15	10	4
Organic P	10	5	2

Parameter	High	Medium	Low
COD total	1,200	750	500
COD soluble	480	300	200
COD suspended	720	450	300
BOD	560	350	230
VFA (as acetate)	80	30	10
N total	100	60	30
Ammonia-N	75	45	20
P total	25	15	6
Ortho-P	15	10	4
TSS	600	400	250
VSS	480	320	200

f raw municipal wastewater
rial wastewater