6. OTHER EFFECTS ON ENZYME ACTIVITY

- Ionic strength
- pH
- TEMPERATURE
- Shear
- Pressure (hydrostatic)
- Surface tension
- Chemicals (alcohol, urea, H_2O_2...)
- Light, sonication, ionising radiations

Reverzible
changes
Irreverzible

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1

Active side chains

Changes in activity of proteins are caused by changes of amino acid side chains.

Acidic: –COOH: Asp, Glu Basic: $-NH_2$: Lys, Arg
(and terminal –COOH and $-NH_2$)
amide: $-CO-NH_2$: Asn, Gln

Polar: –OH: Ser, Thr -SH: Cys, $-S-CH_3$: Met

Imidazole: His Guanidin: Arg

H-bonds: C=O …… H-O- C=O …… H-NH-

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2

Effect of pH

Proteins: + and – charged side chains ← their charge depends on dissociation ← determined by pH → it effects the active centre.

Recharge of enzyme:

$$E \underset{+H^+}{\overset{-H^+}{\rightleftharpoons}} E^- \underset{+H^+}{\overset{-H^+}{\rightleftharpoons}} E^{2-}$$

$$E \rightleftharpoons E^- + H^+$$

$$E^- \rightleftharpoons E^{2-} + H^+$$

$$K_1 = \frac{H^+ \cdot E^-}{E}$$

$$K_2 = \frac{H^+ \cdot E^{2-}}{E^-}$$

$$E_0 = E + E^- + E^{2-}$$

Only E^- is active!

Ratio of active enzymes: $Y^- = E^- / E_0$

Michaelis-féle pH függvények:

$$Y^- = \frac{1}{1 + H^+/K_1 + K_2/H^+}$$

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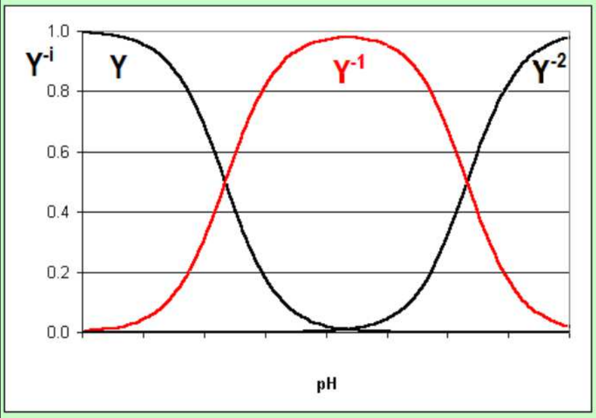
3

Effect of pH



$$Y^- = \frac{1}{1 + H^+/K_1 + K_2/H^+}$$

$$H^+_{optimum} = \sqrt{K_1 K_2}$$

$$(pH)_{optimum} = \frac{1}{2}(pK_1 + pK_2)$$

$$V_{max} = k_2 E_0 Y^- = k_2 E_0 \frac{1}{1 + H^+/K_1 + K_2/H^+}$$

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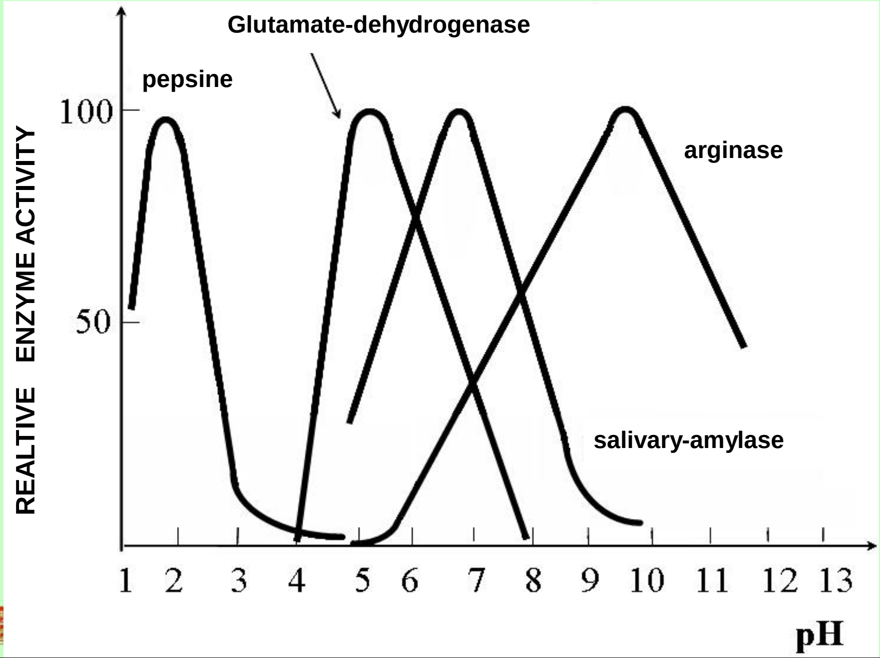
4

Effect of pH



5

Effect of pH temperature

Double effect → Increasing reaction rate

Double effect → decrease: denaturation → irreversible / reversible

decrease: denaturation ↓ depends on treatment time, too!

$$\frac{dE_a}{dt} = -kE_a \longrightarrow E_a(t) = E_{a0}e^{-kt}$$

6

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Effect of pH temperature

$$E_a \underset{}{\overset{K_d}{\rightleftarrows}} E_i$$

$$\frac{E_i}{E_a} = K_d = \exp\left(\frac{-\Delta G_d}{RT}\right) = \exp\left(\frac{-\Delta H_d}{RT}\right)\exp\left(\frac{\Delta S_d}{R}\right)$$

S_d = ~900 KJ/mol.K

H_d = 280-310 KJ/mol

Large: sensitively reacts on small change (one H-bond: 12,5-29,3 kJ/mol)

If: $V_{max} = k_2(T)E_a$

$E_0 = E_a + E_i \rightarrow E_a = \frac{E_0}{1+K_d}$

and $k_2(T) = \beta\left(\frac{k_B T}{h}\right)e^{\Delta S^*/R} \cdot e^{-E/RT}$

$$V_{max} = \frac{\alpha T e^{-E/RT}}{1 + e^{\Delta S^*/R} \cdot e^{-\Delta H_d/RT}}$$

α = combination of (β,k_B,h,E_0,ΔS*)

K_m also depends on T!

7

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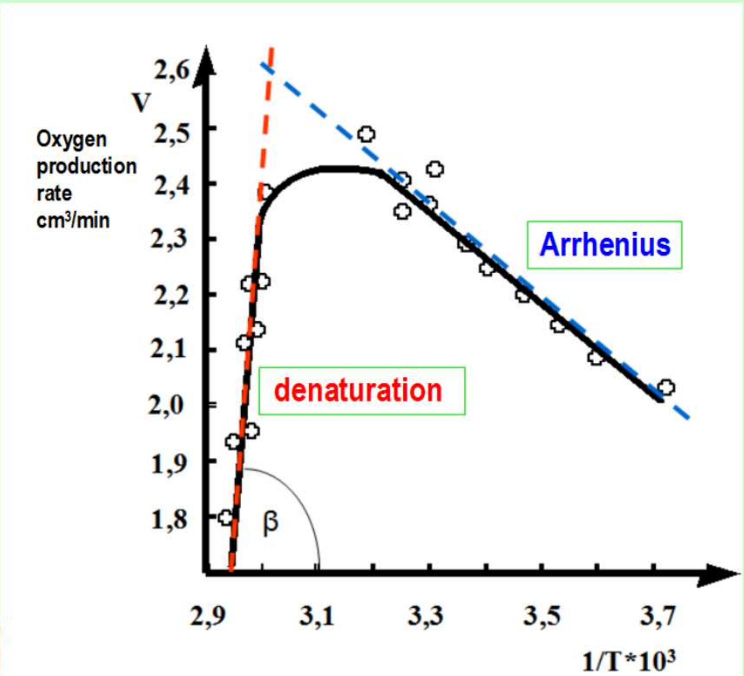
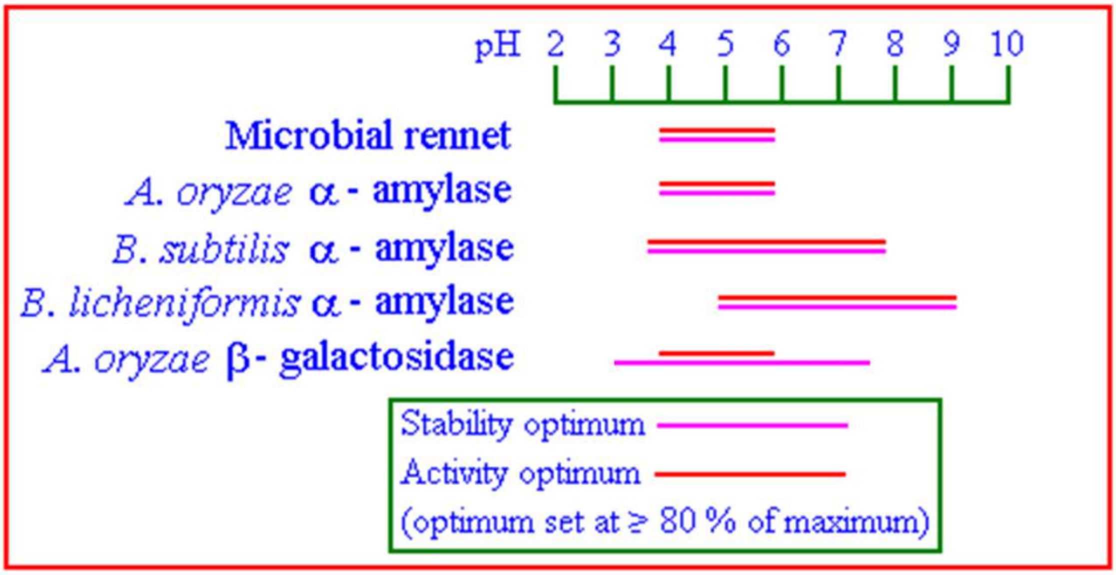
Effect of pH temperature



8

pH optimum and stability



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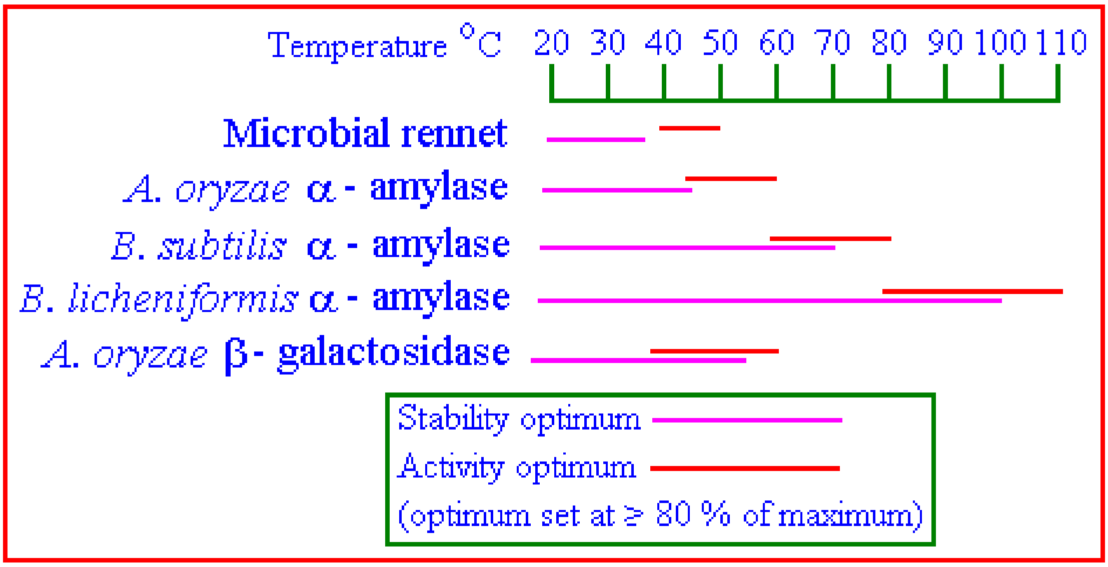
Temperature optimum and stability



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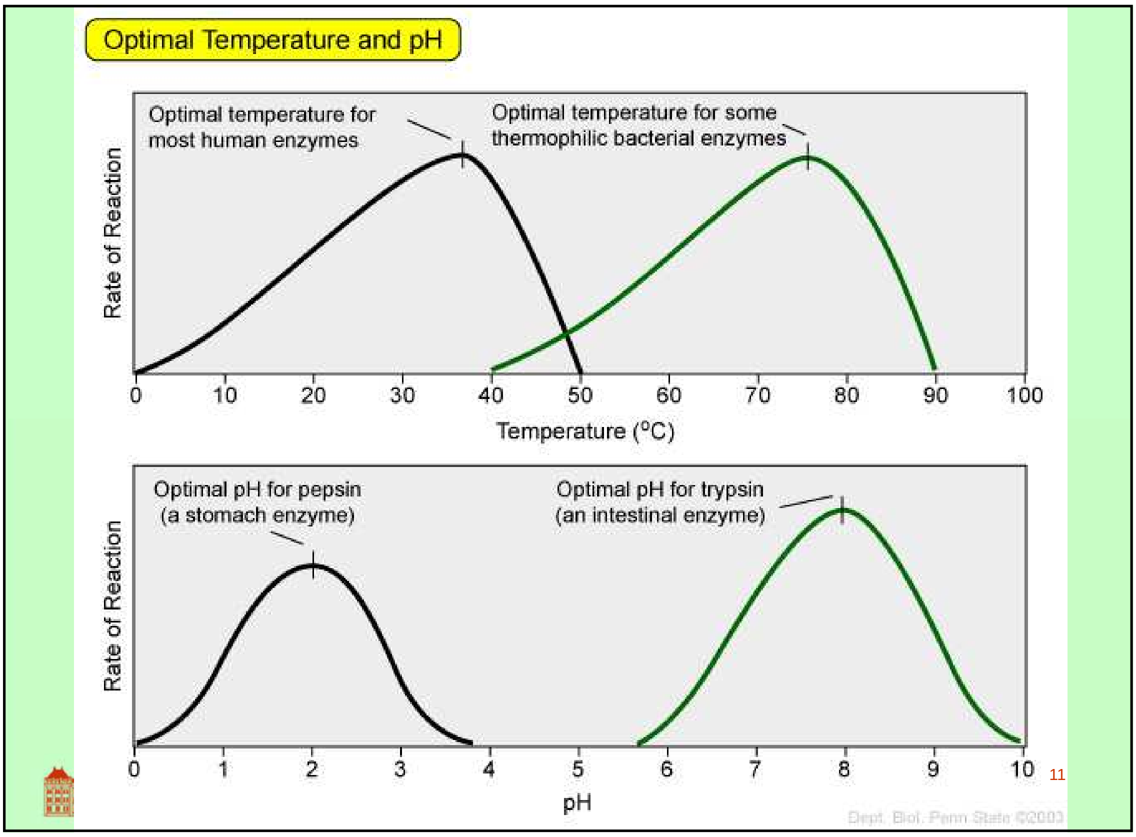
Optimal Temperature and pH
Optimal temperature for most human enzymes
Optimal temperature for some thermophilic bacterial enzymes
Rate of Reaction
0
10
20
30
40
50
60
70
80
90
100
Temperature (°C)
Optimal pH for pepsin (a stomach enzyme)
Optimal pH for trypsin (an intestinal enzyme)
Rate of Reaction
0
1
2
3
4
5
6
7
8
9
10
pH
11
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