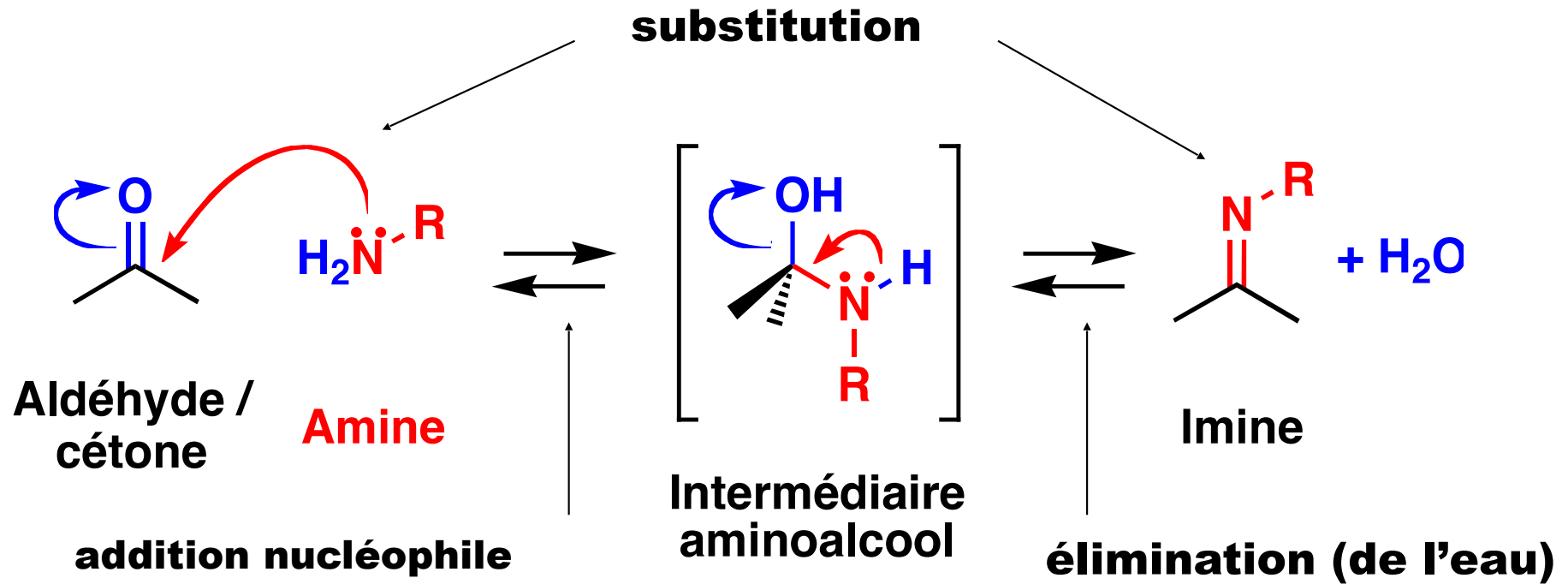
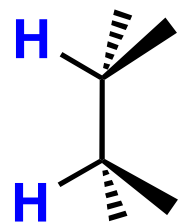


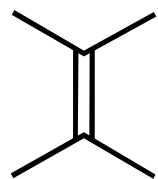
Substitution Nucléophile : Imines



Imines : Réduction

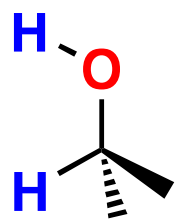


Réd



Alcane

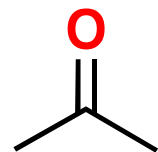
Alcène



Ox

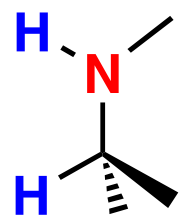


Réd

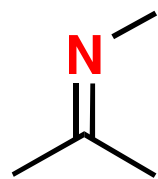


Alcool

Dérivé
carbonylé

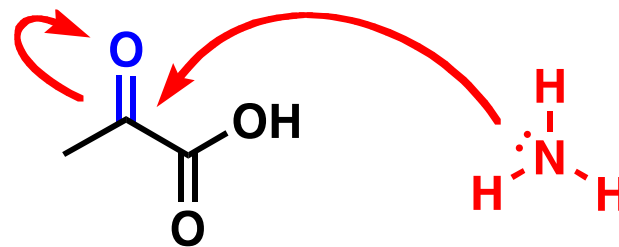


Réd

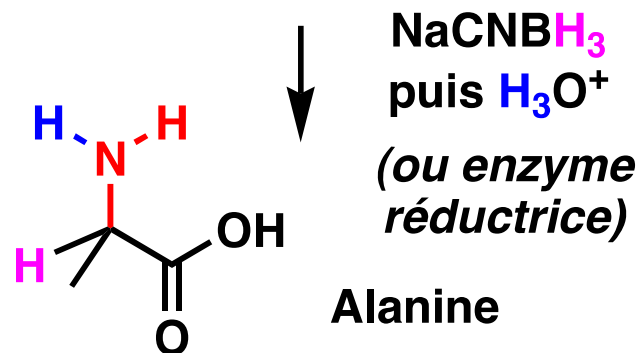
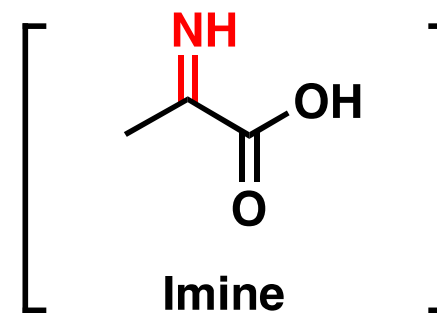
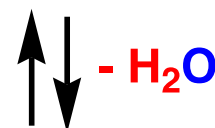


Amine

Imine

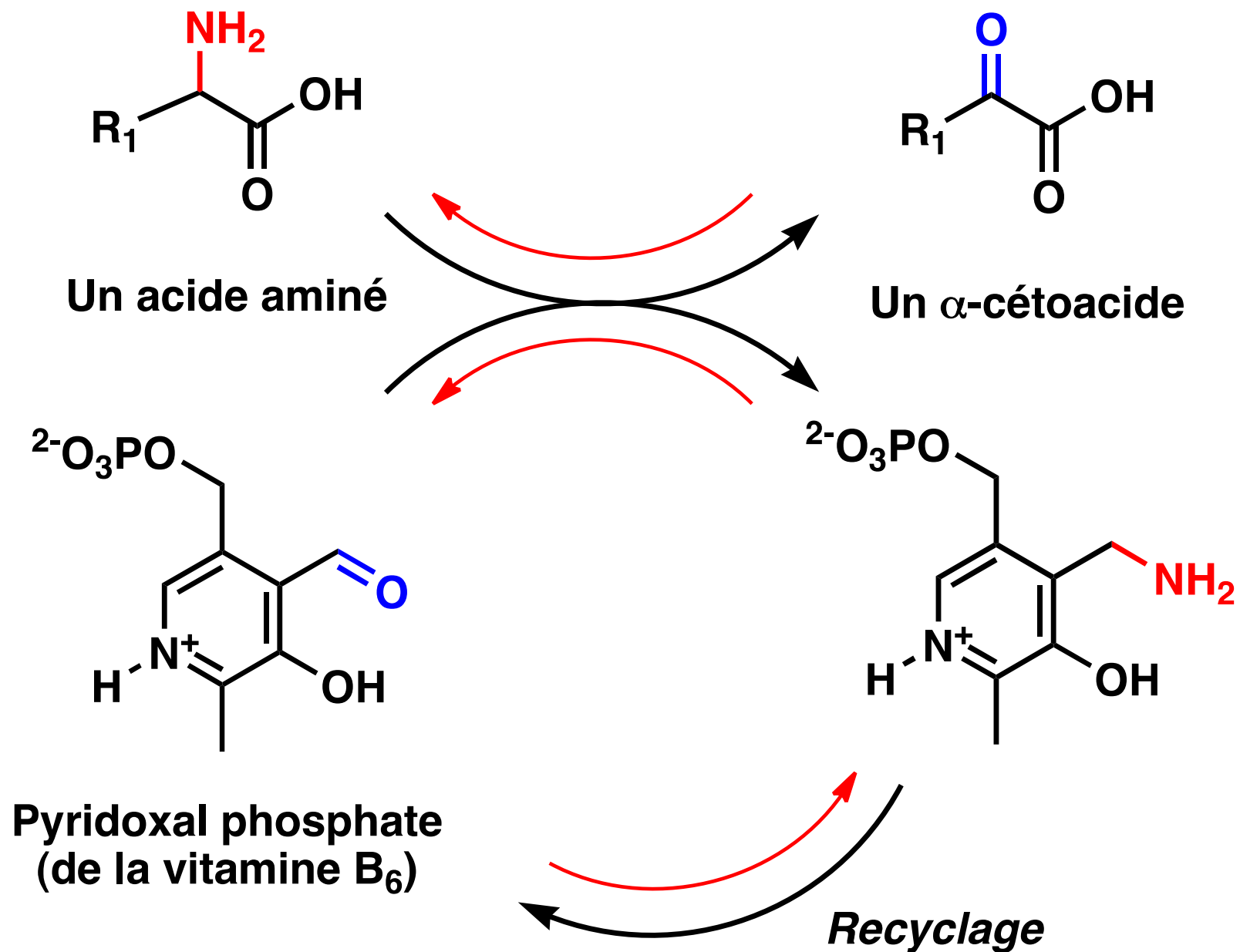


Acide pyruvique
(Glycolyse, 552)



NaCNBH₃
puis H₃O⁺
(ou enzyme
réductrice)
Alanine

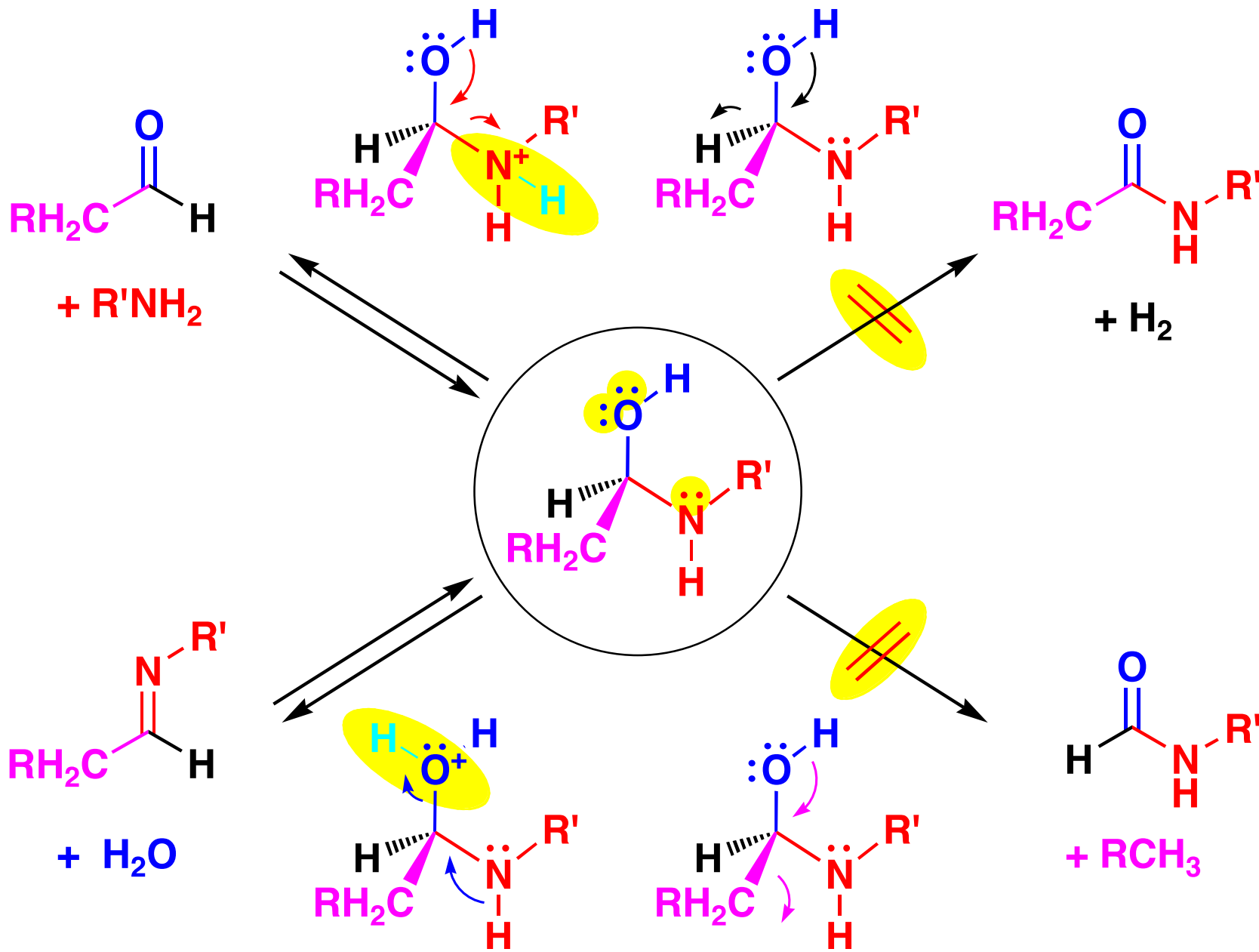
Imines : Transamination



Substitution nucléophile et groupes partants

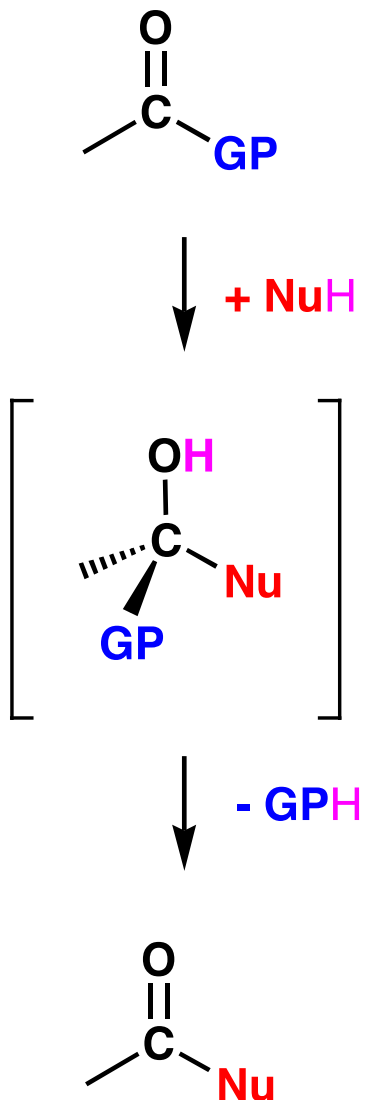
222,
227,
231

(226,
232,
236)



Sélectivité

**Groupes partants
(groupes sortants,
nucléofuges)**



<i>Groupe partant</i>		<i>Acide conjuguée</i>	pK_a	
	\rightarrow	I^-	HI	-5,2
	\rightarrow	Br^-	HBr	-5,0
	\rightarrow	Cl^-	HCl	-2,2
	\rightarrow	H_2O	H_3O^+	-1,7
	\rightarrow	NH_3	NH_4^+	9,3
	\rightarrow	CH_3O^-	CH_3OH	15,5
	\rightarrow	OH^-	H_2O	15,7
	\rightarrow	NH_2^-	NH_3	35
	\rightarrow	H^-	H_2	35
	\rightarrow	CH_3^-	CH_4	~ 50
	\rightarrow	O^{2-}	OH^-	?

Bon groupe partant

Mauvais groupe partant

Résumé acides et bases















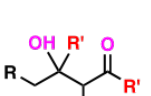



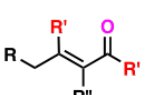


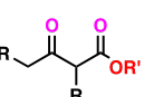


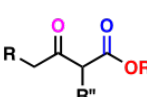
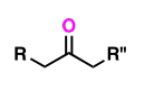


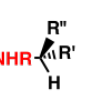








	Acide	pK_a	Base conjuguée	Acide	pK_a	Base conjuguée	
	<chem>CCN</chem>	>25	<chem>CC[NH-]</chem>	<chem>CCC</chem>	>25	<chem>CC[CH-]C</chem>	Base conjuguée forte
	Amine (alkyle)			Alcane			
	<chem>CC(=O)N</chem>	>25	<chem>CC(=O)[NH-]</chem>	<chem>CCC(=O)C</chem>	20	<chem>CCC(=O)[O-]</chem>	
	Amide			Cétone (Aldehyde, Ester)		Énolate	
	<chem>CC[NH3+]</chem>	10	<chem>CCN</chem>	<chem>CCO</chem>	15	<chem>CC[O-]</chem>	
	Ammonium (alkyle)		Amine (alkyle)	Alcool		Alcoolate	
	<chem>c1ccccc1[NH3+]</chem>	5	<chem>c1ccccc1N</chem>	<chem>c1ccccc1O</chem>	10	<chem>c1ccccc1[O-]</chem>	
	Ammonium (aryle)		Amine (aryle)	Phénol		Phénolate	
	<chem>CC(=O)[NH3+]</chem>	<1	<chem>CC(=O)N</chem>	<chem>CC(=O)O</chem>	5	<chem>CC(=O)[O-]</chem>	
	Acide fort		Amide	Acide carboxylique		Carboxylate	
				<chem>c1ccccc1C(=O)O</chem>	5	<chem>c1ccccc1C(=O)[O-]</chem>	
				Acide benzoïque		Benzoate	
				<chem>CC[OH2+]</chem>	<1	<chem>CCO</chem>	Base conjuguée faible
				Alcool			
pK_a	8						
<chem>CCS</chem>	Thiol (Cys)		<chem>CC[S-]</chem>	Thiolate (Cys)			

Résumé 5 (Glucides – aldéhydes - cétones - imines -)

- réactions :

- **addition - élimination - substitution - diagramme d'énergie -**
- **état de transition - intermédiaire réactionnel - mécanisme -**
- **nucléophile - électrophile - catalyse - groupes protecteurs - groupes partants**
- **addition nucléophile : aldéhyde / cétone +**
 - **H₂O : hydrate; alcool : hémiacétal**
- **substitution nucléophile : aldéhyde / cétone +**
 - **2 x alcool : acétal**
- **glucides : aldose - cétose - hexose - pentose - pyranose -**
 - **furanose - projection de Haworth - anomère - glycoside**
- **intermédiaires réactionnels : médicaments antiviraux, antidiabétiques**
- **substitution nucléophile : aldéhyde / cétone +**
 - **amines : imines - réduction - transamination - pyridoxal phosphate -**
 - **chimie de la vision**

Résumé des réactions

										2007	2003
	$\xrightarrow{\text{H}_2, \text{catalyseur}}$		4.6	4.6		+ ROH	$\xrightleftharpoons[\text{Catalyseur (OH}^- \text{ ou H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		+ H ₂ O	10.8	10.6
Alcène		Alcane			Acide carboxylique	Alcool		Ester		10.11	10.9
	$\xrightleftharpoons[\text{LiAlH}_4, \text{ puis H}_3\text{O}^+]{\text{CrO}_3, \text{ H}_3\text{O}^+}$		8.5	8.7		+ R'NH ₂	$\xrightleftharpoons[\text{Chauffage, catalyseur (OH}^- \text{ ou H}_3\text{O}^+)]{\text{Chauffage, catalyseur (OH}^- \text{ ou H}_3\text{O}^+)}$		+ ROH	16.13	10.9
Alcool primaire		Acide carboxylique			Ester	Amine		Amide	Alcool	10.10	10.10
	$\xrightleftharpoons[\text{NaBH}_4, \text{ puis H}_3\text{O}^+]{\text{Na}_2\text{Cr}_2\text{O}_7, \text{ H}_3\text{O}^+}$		8.5	8.7			$\xrightarrow{\text{LiAlH}_4, \text{ puis H}_3\text{O}^+}$		+ ROH	10.11	10.9
Alcool secondaire		Cétone			Ester			Alcool primaire	Alcool	8.4	8.5
	$\xrightleftharpoons[\text{NaBH}_4, \text{ puis H}_3\text{O}^+]{\text{PCC}}$		8.5	8.7	$2 \text{ R-CH}_2\text{-C(=O)-R}'$		$\xrightleftharpoons[\text{Catalyseur (OH}^-)]{\text{Catalyseur (OH}^-)}$			11.9	11.8
Alcool primaire		Aldéhyde			Aldéhyde / cétone			β-Hydroxycétone			
	$\xrightarrow{\text{Na}_2\text{Cr}_2\text{O}_7, \text{ H}_3\text{O}^+}$		8.6	8.8			$\xrightarrow{\text{Catalyseur (OH}^- \text{ ou H}_3\text{O}^+)}$		+ H ₂ O	11.10	11.9
Phénol		Benzoquinone			β-Hydroxycétone			Énone conjuguée			
	$\xrightleftharpoons[\text{NaBH}_4, \text{ puis H}_3\text{O}^+]{\text{Na}_2\text{Cr}_2\text{O}_7, \text{ H}_3\text{O}^+}$		8.6	8.8	$2 \text{ R-CH}_2\text{-C(=O)-OR}'$		$\xrightleftharpoons[\text{Catalyseur (NaOR}')] {\text{Catalyseur (NaOR}')}$		+ R'OH	11.11	11.10
Hydroquinone		Benzoquinone			Ester			β-Cétoester	Alcool		
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.7	9.7			$\xrightarrow{\text{Chauffage, catalyseur (OH}^- \text{ ou H}_3\text{O}^+)}$		+ R'OH + CO ₂	17.4	17.4
Aldéhyde / cétone		Hydrate			β-Cétoester			Cétone			
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.8	9.8	$\text{RNH}_2 + \text{R}''\text{-CH}_2\text{-CH(OH)-GP}$		$\xrightarrow{\text{NaCNBH}_3, \text{ puis H}_3\text{O}^+}$		+ HGP ⁺	12.4	12.4
Aldéhyde / cétone		Hémiacétal			Amine	GP = groupe partant		Alkylamine		7.5	7.7
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.9	14.5						9.10	9.11
Aldéhyde / cétone		Acétal		14.6	Imine			Amine			
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.8	9.8							
Aldéhyde / cétone		Acétal		14.7							
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.9	14.8							
Aldéhyde / cétone		Acétal		14.8							



CONTENU

McMurry

1. Généralités

(1, 2, 15)

2. Lipides - stéroïdes - alcanes -

(2 - 5, 16)

alcènes - arènes -

3. Glucides - stéréochimie -

(6, 14)

4. Alcools - éthers - phénols -

(8, 16)

hydroquinones - thiols - disulfures

5. Glucides - aldéhydes - cétones -

(9, 14)

imines -

6. Protéines - lipides -

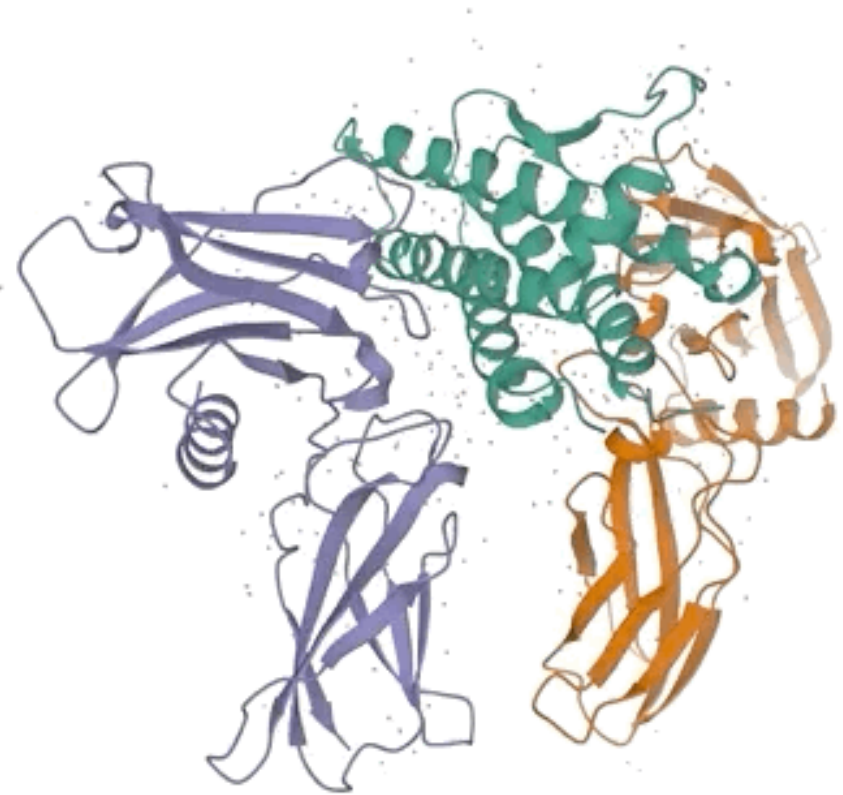
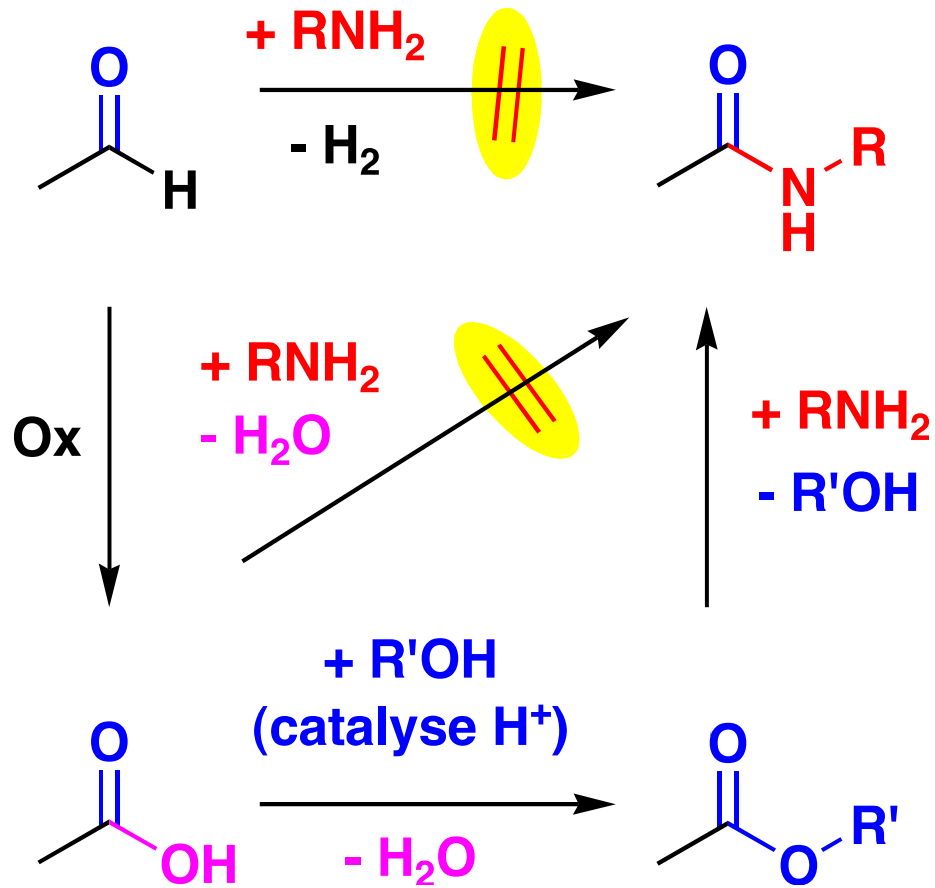
(10, 11, 15, 16)

acides - esters - amides -

7. Acides nucléiques - amines -

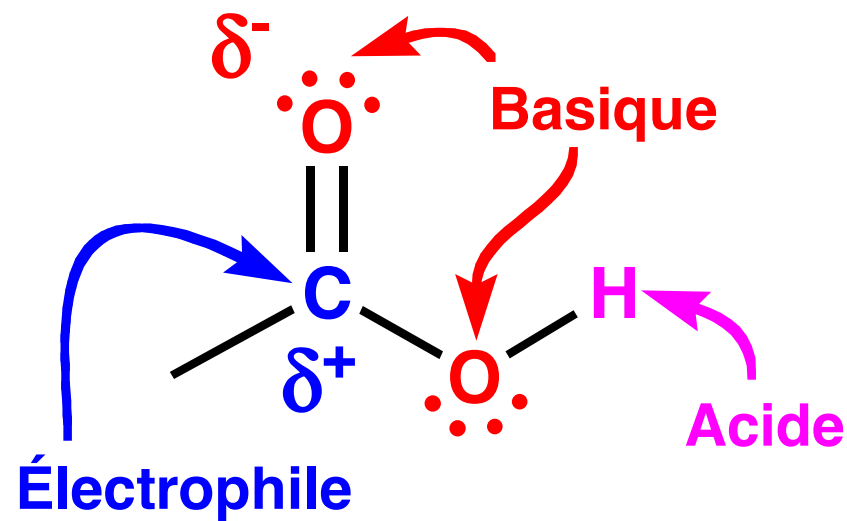
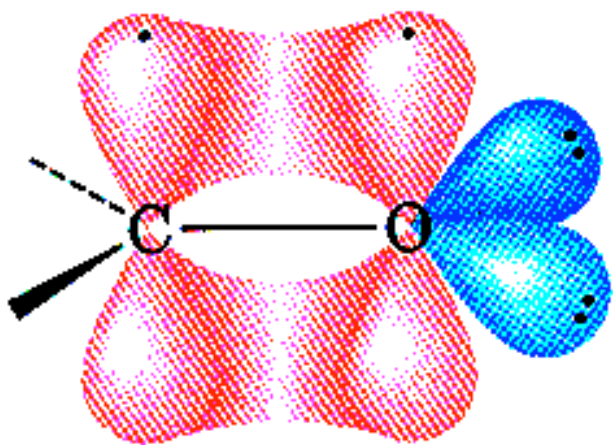
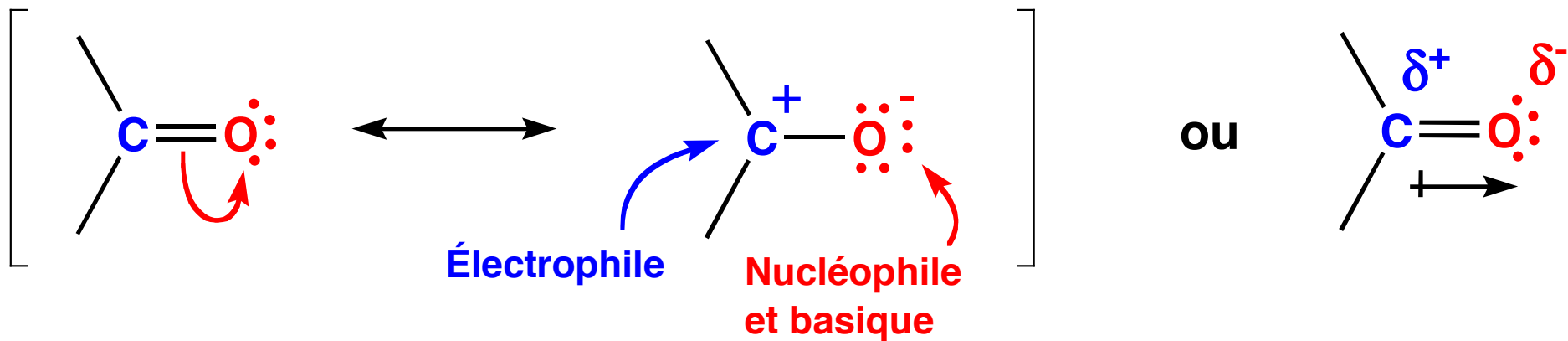
(12, 16)

Synthèse des protéines

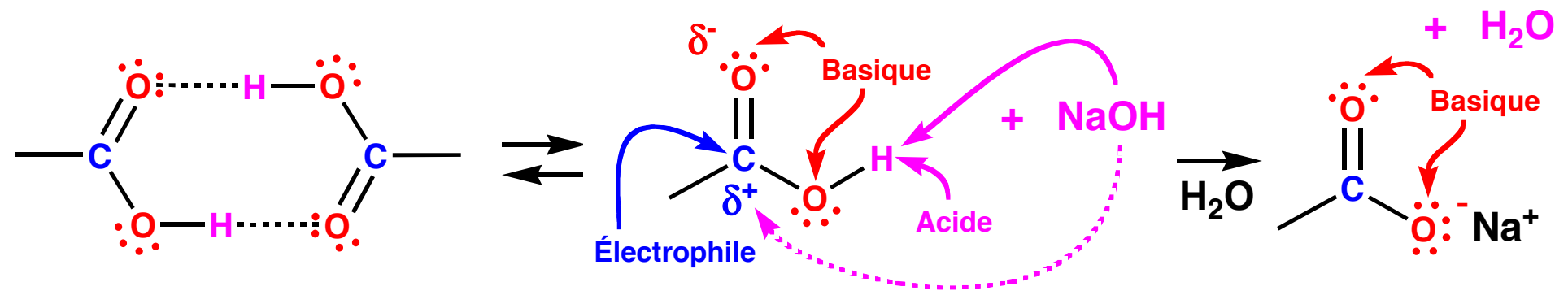


Erythropoietin
(EPO, hormone, anemia)

Acide carboxylique



Liaisons hydrogènes et solubilité



dimère d'un acide
carboxylique

acide carboxylique

sel de l'ion
carboxylate

acide acétique : Eb = 118 °C

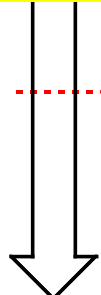
insoluble dans l'eau

soluble dans l'eau

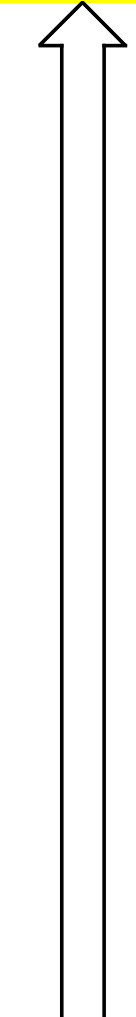
Résumé acides et bases

	Acide	pK _a	Base conjuguée	Acide	pK _a	Base conjuguée	
	<chem>CCN</chem>	>25	<chem>CC[NH-]</chem>	<chem>CCC</chem>	>25	<chem>CC[CH-]</chem>	Base conjuguée forte
	Amine (alkyle)			Alcane			
	<chem>CC(=O)N</chem>	>25	<chem>CC(=O)[NH-]</chem>	<chem>CCC(=O)C</chem>	20	<chem>CCC(=O)[CH-]</chem>	
	Amide			Cétone (Aldehyde, Ester)		Énolate	
	<chem>CC[NH3+]</chem>	10	<chem>CCN</chem>	<chem>CCO</chem>	15	<chem>CC[O-]</chem>	
	Ammonium (alkyle)		Amine (alkyle)	Alcool		Alcoolate	
	<chem>c1ccccc1[NH3+]</chem>	5	<chem>c1ccccc1N</chem>	<chem>c1ccccc1O</chem>	10	<chem>c1ccccc1[O-]</chem>	
	Ammonium (aryle)		Amine (aryle)	Phénol		Phénolate	
	<chem>CC(=O)[NH3+]</chem>	<1	<chem>CC(=O)N</chem>	<chem>CC(=O)O</chem>	5	<chem>CC(=O)[O-]</chem>	
	Acide fort		Amide	Acide carboxylique		Carboxylate	
				<chem>c1ccccc1C(=O)O</chem>	5	<chem>c1ccccc1C(=O)[O-]</chem>	
				Acide benzoïque		Bénzoate	
				<chem>CC[OH2+]</chem>	<1	<chem>CCO</chem>	Base conjuguée faible
				Alcool			

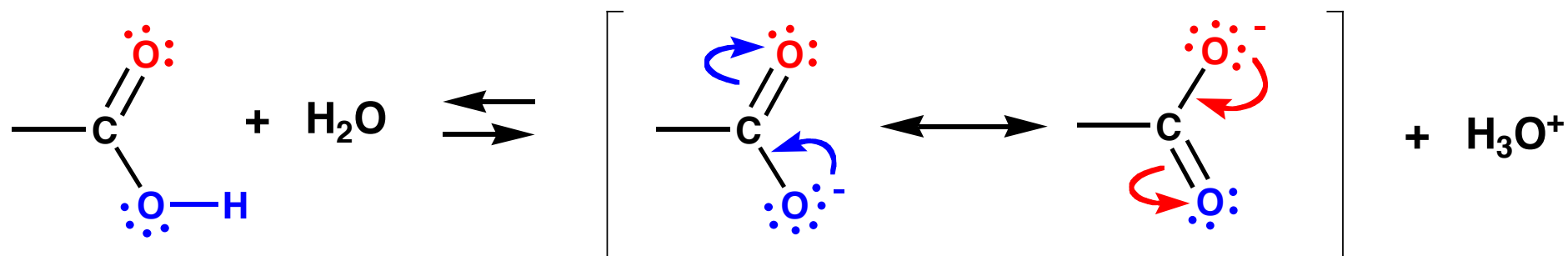
Acide faible



Acide fort

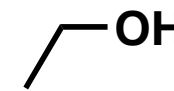
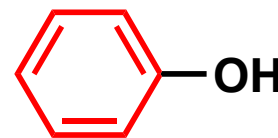
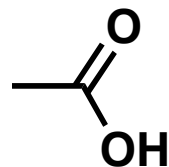
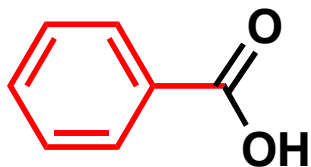


Acidité et résonance



acide carboxylique

ion carboxylate stabilisé par résonance
(deux mésomères équivalents)

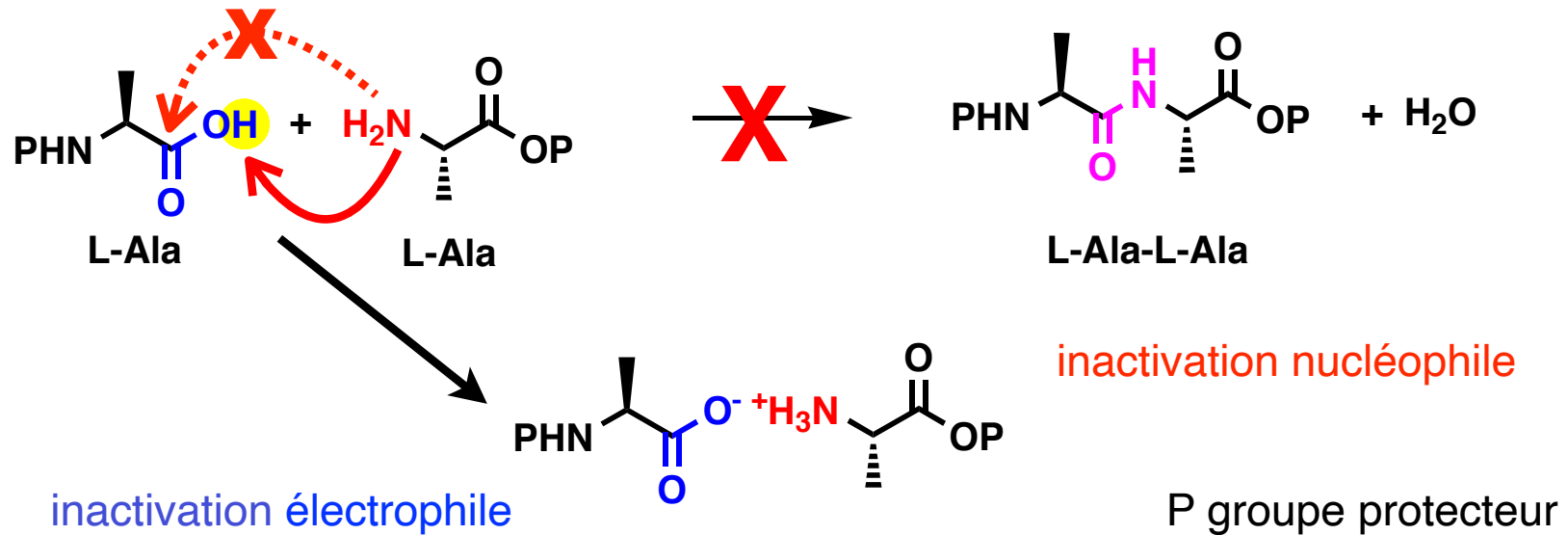
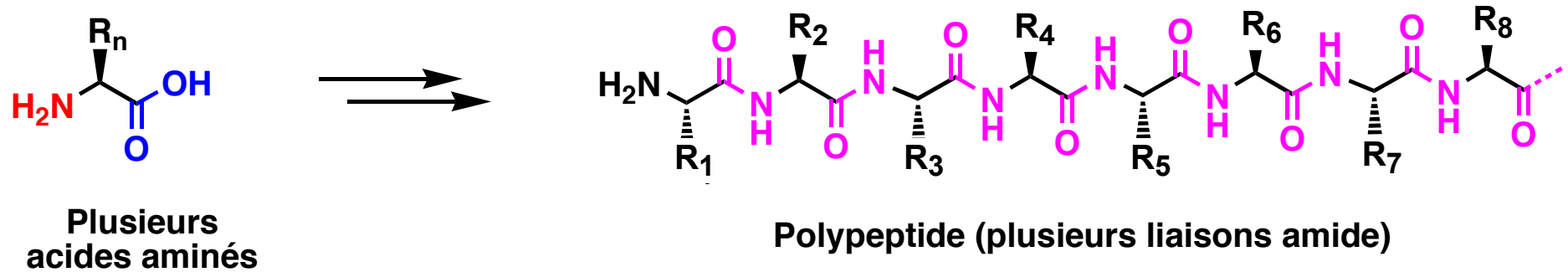


$pK_a \sim 5$

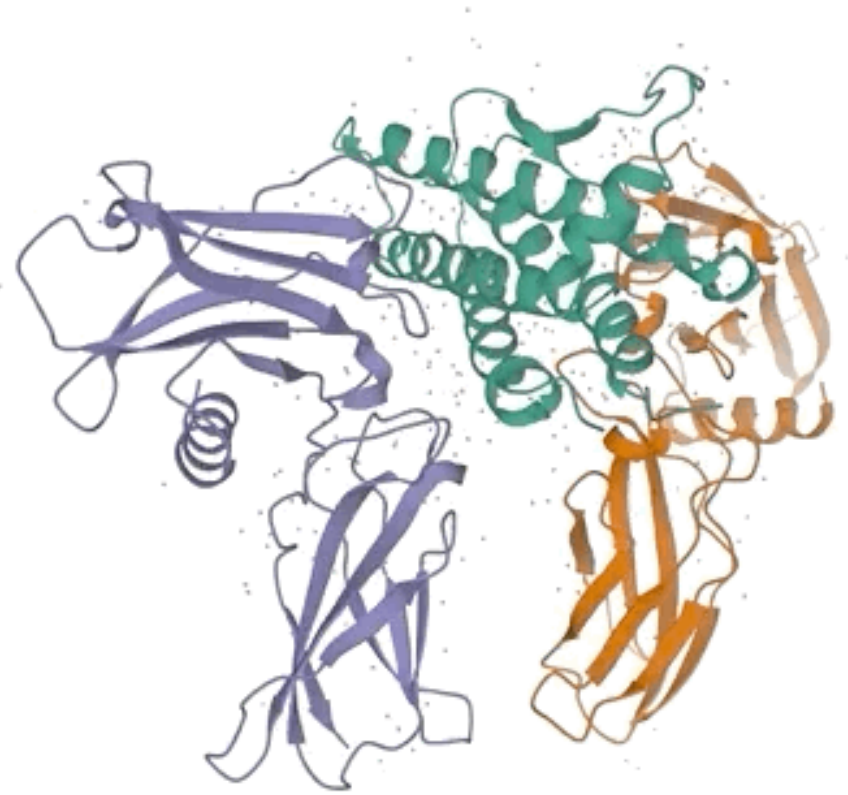
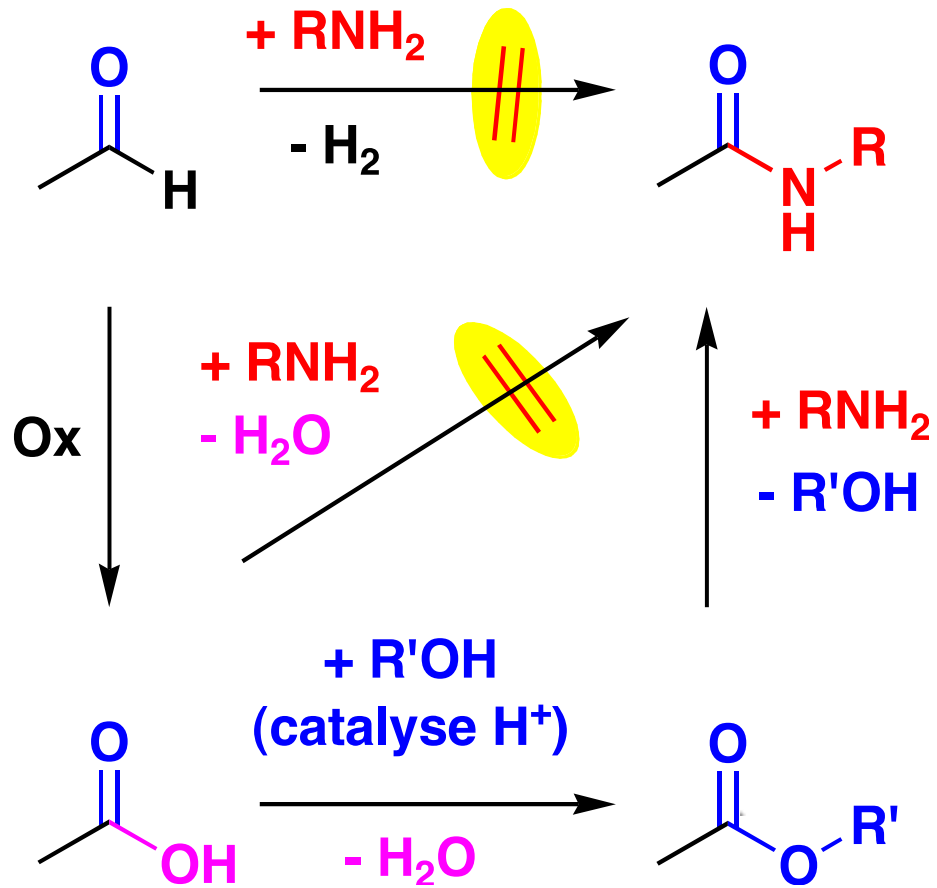
$pK_a \sim 10$

$pK_a \sim 15$

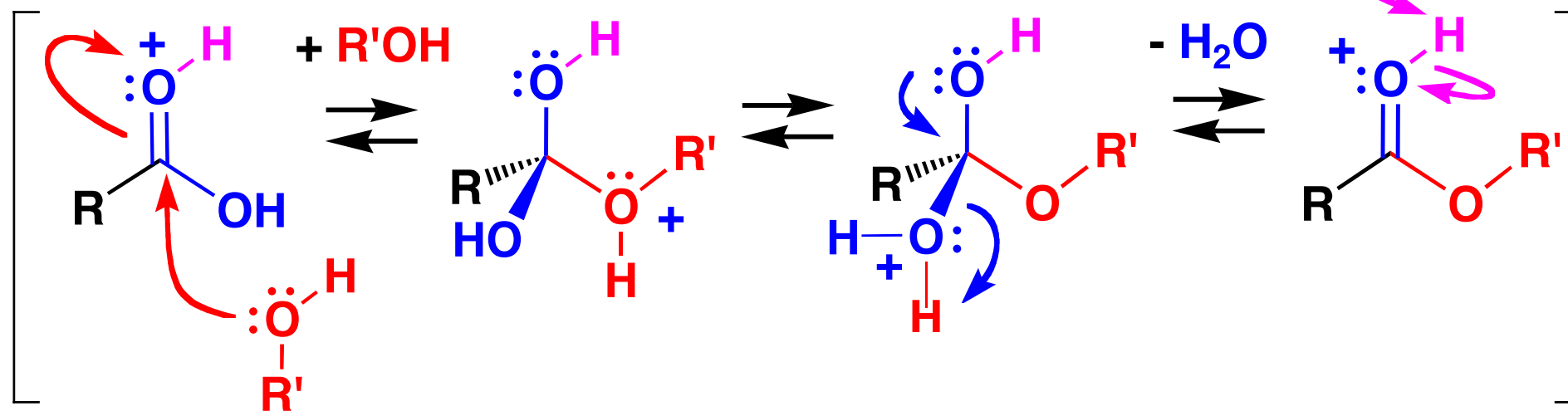
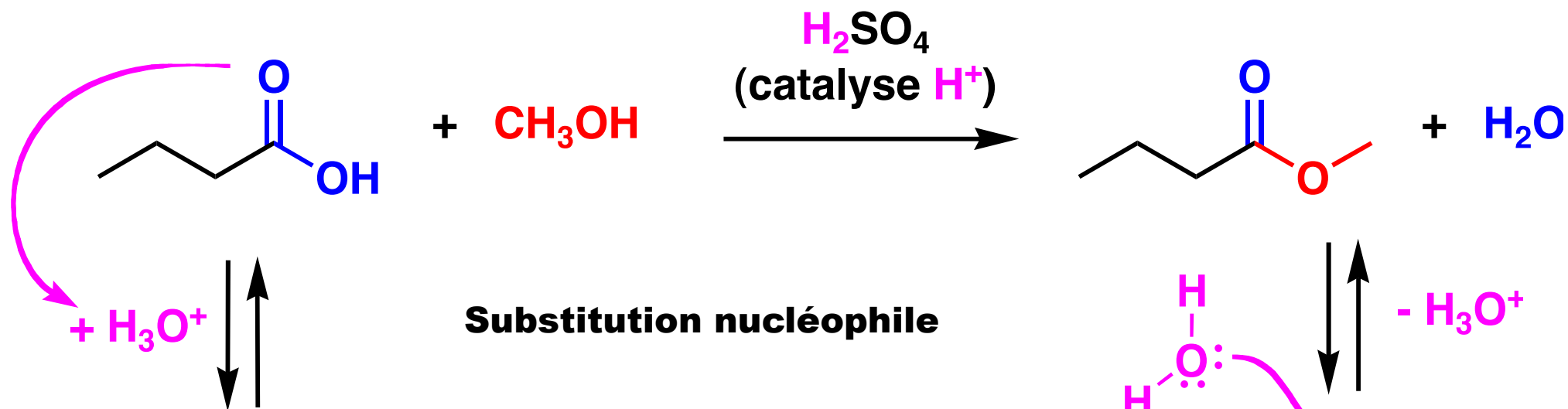
Synthèse des protéines



Synthèse des protéines



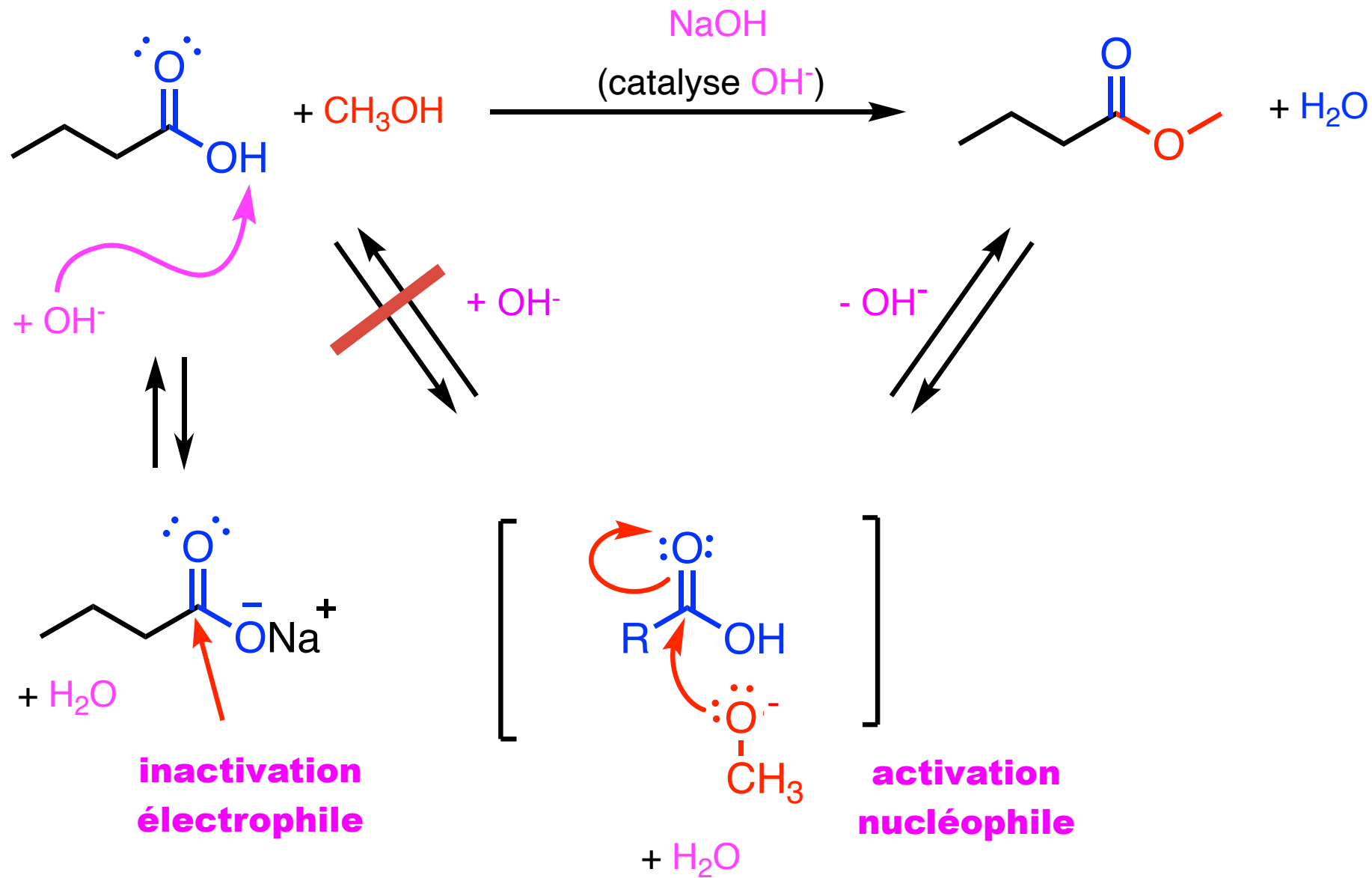
L'estérification de Fischer - catalyse acide



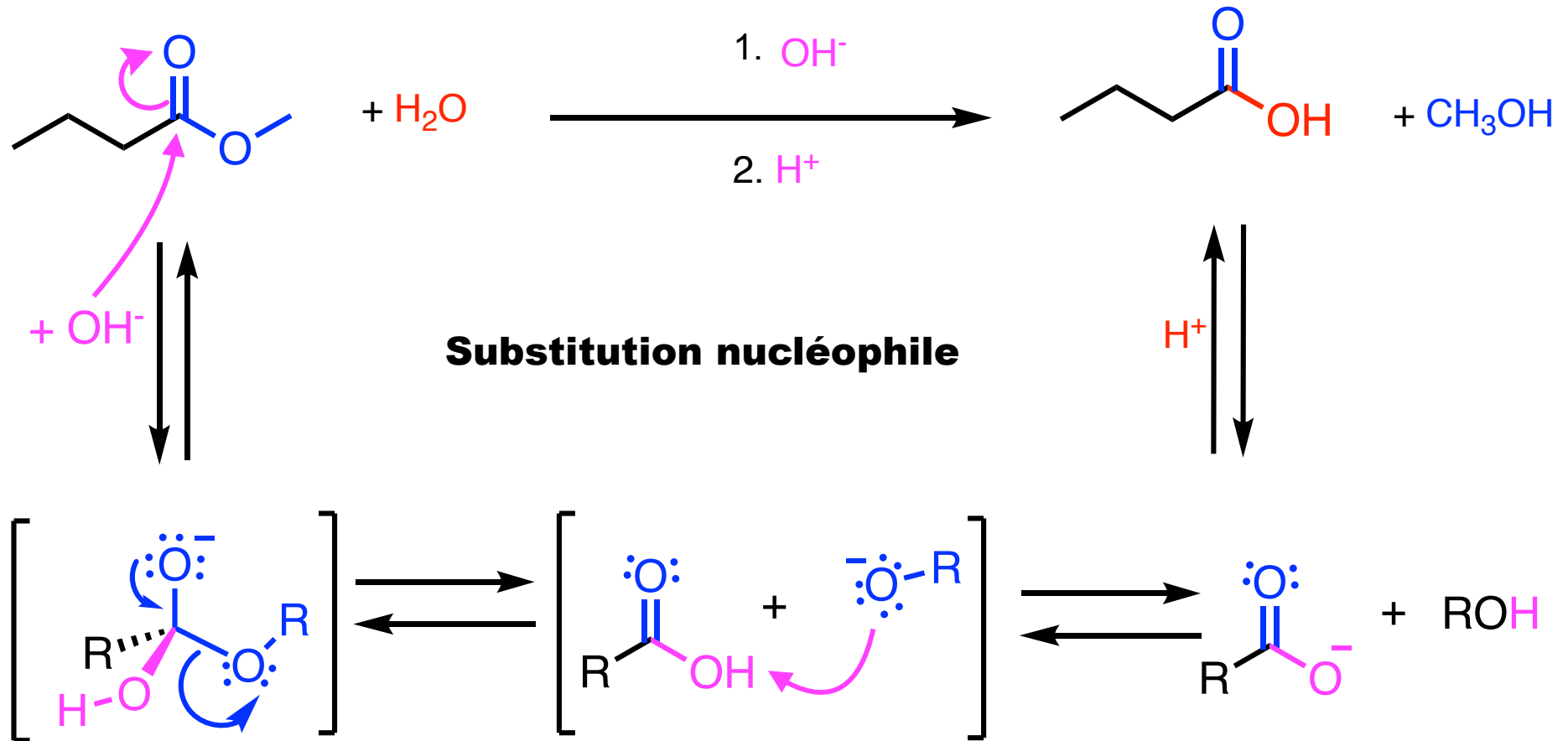
activation
électrophile

activation
groupe partant

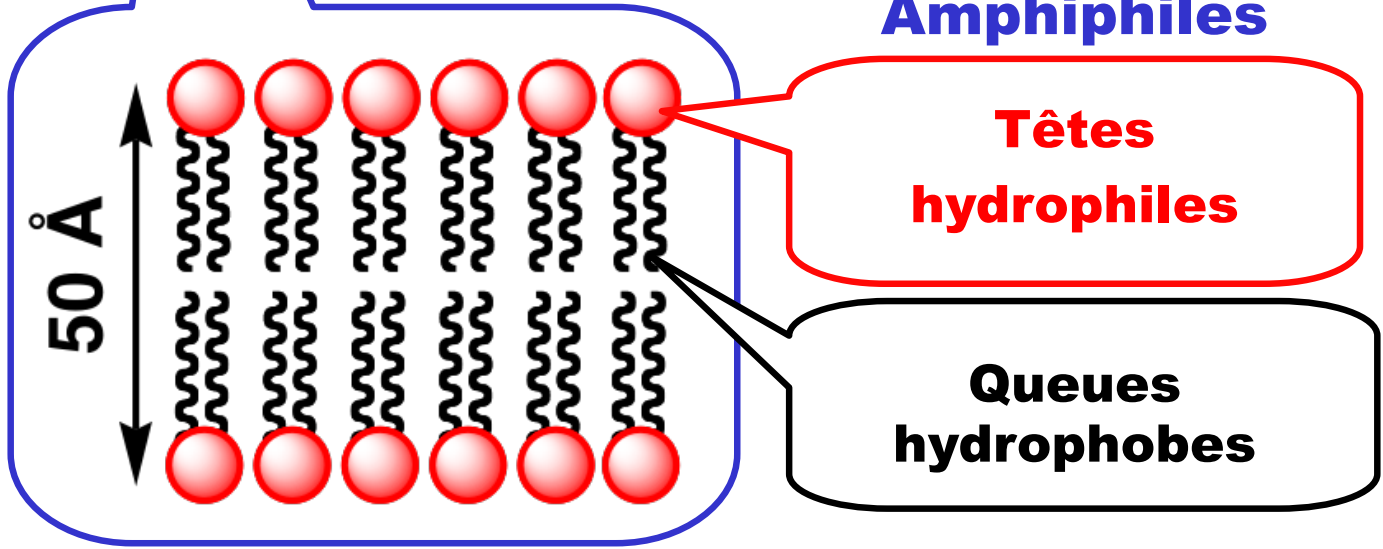
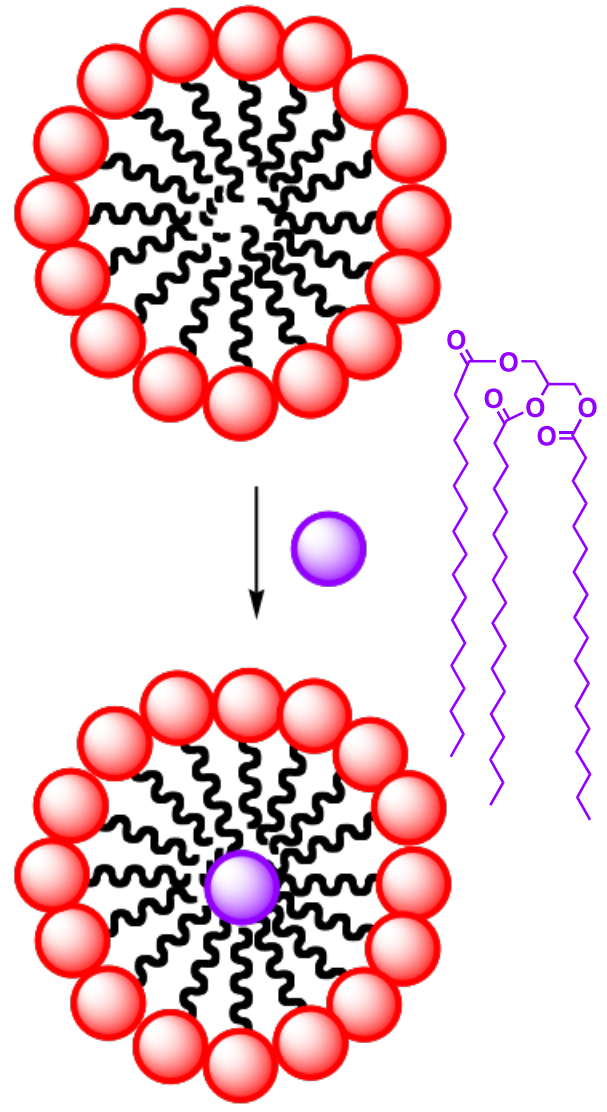
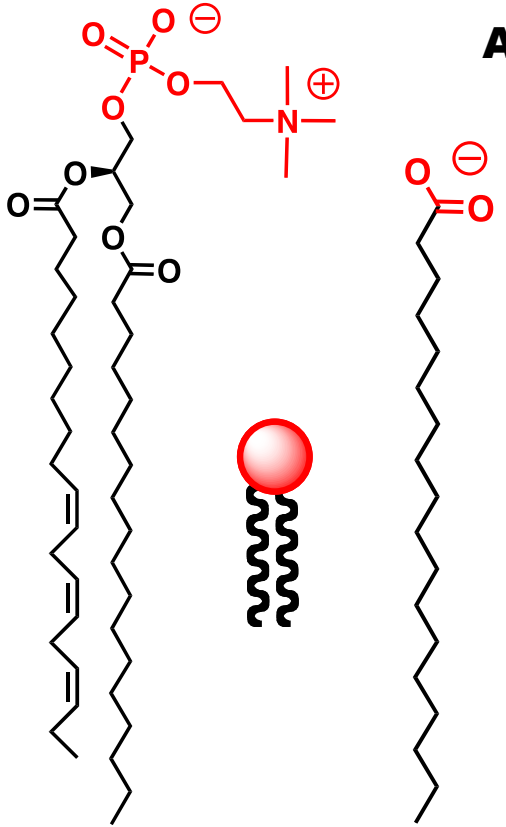
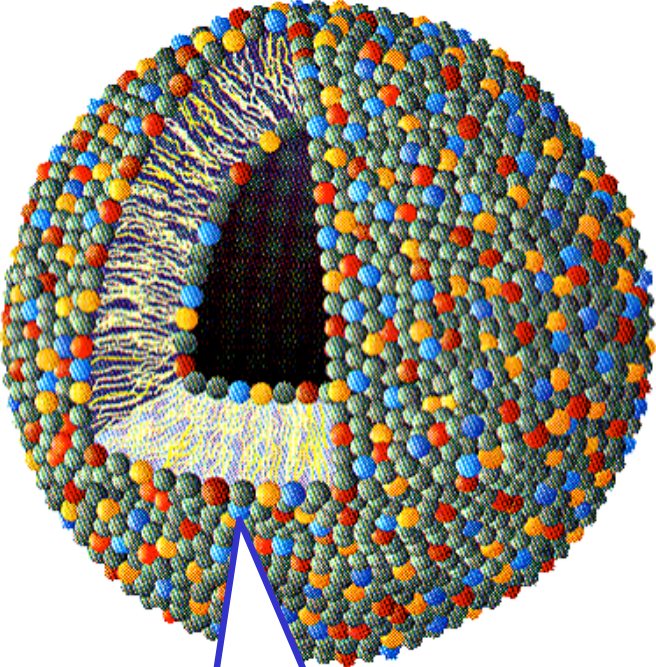
Estérification de Fischer - ~~catalyse basique~~



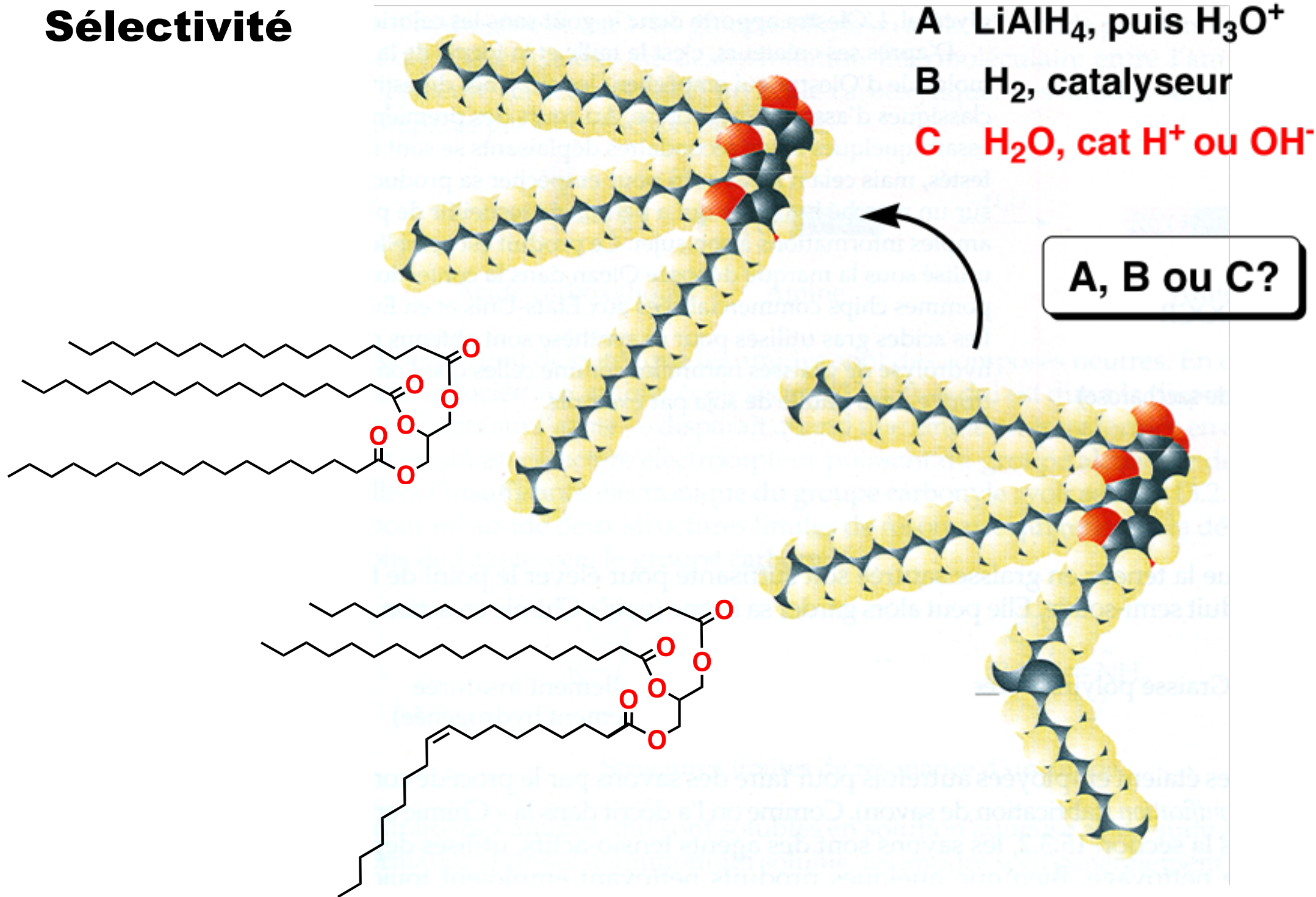
Hydrolyse des esters - conditions basique (saponification)



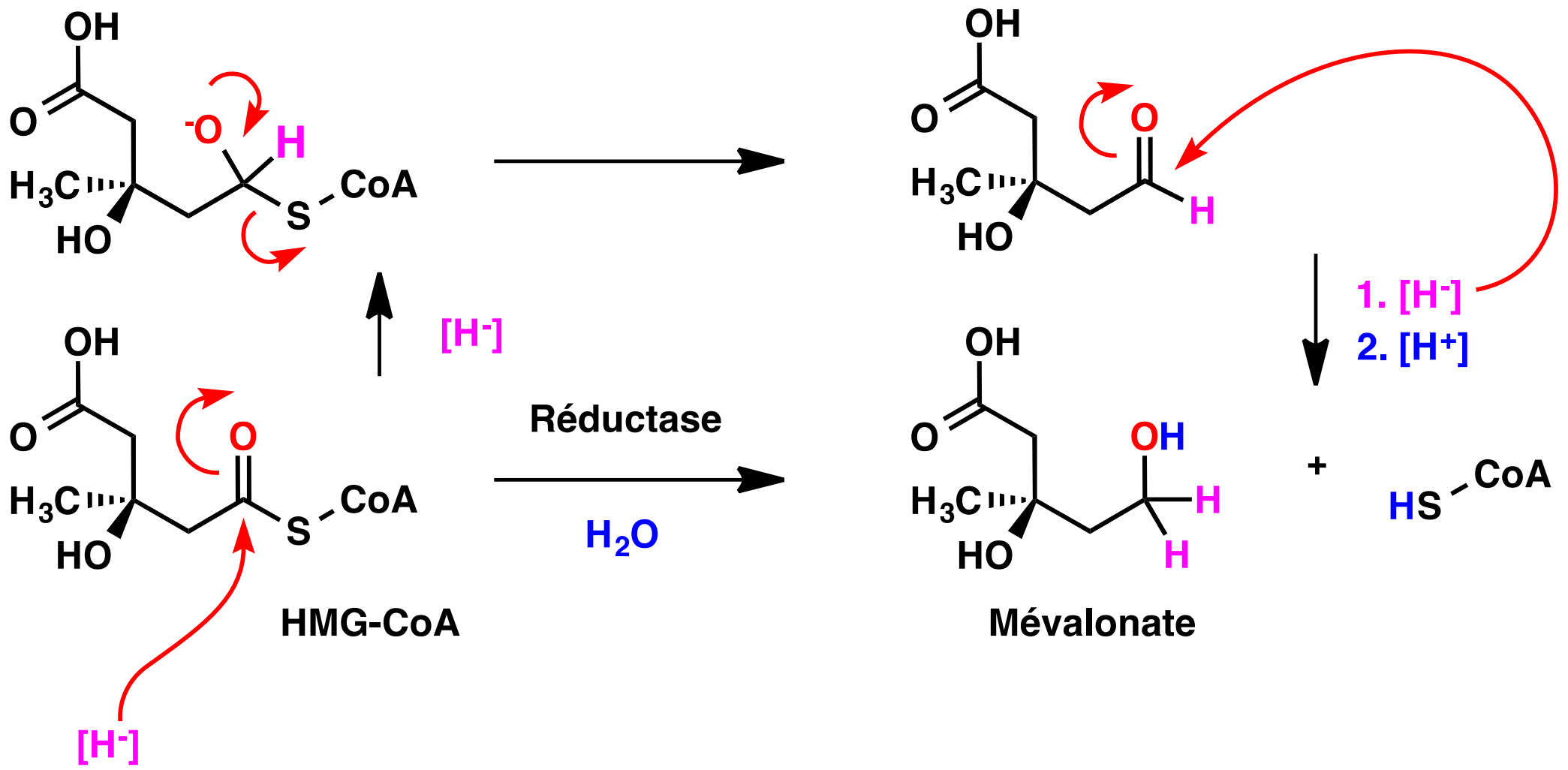
Acides gras et phospholipides micelles et biomembranes savon et cellules



Sélectivité



Réduction des (thio)esters : addition nucléophile d'hydrures



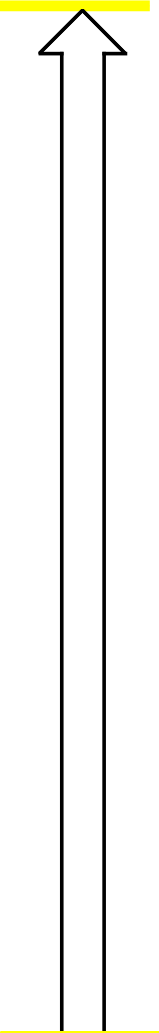
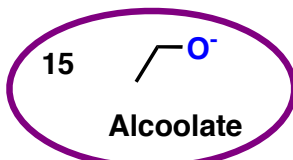
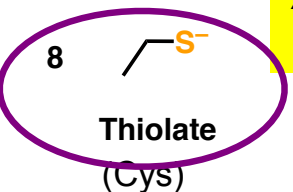
Résumé acides et bases

	Acide	pK _a	Base conjuguée	Acide	pK _a	Base conjuguée	
	<chem>CCN</chem>	>25	<chem>CC[NH-]</chem>	<chem>CCC</chem>	>25	<chem>CC[CH-]</chem>	Base conjuguée forte
	Amine (alkyle)			Alcane			
	<chem>CC(=O)N</chem>	>25	<chem>CC(=O)[NH-]</chem>	<chem>CCC(=O)C</chem>	20	<chem>CCC(=O)[CH-]</chem>	
	Amide			Cétone (Aldehyde, Ester)		Énolate	
	<chem>CC[NH3+]</chem>	10	<chem>CCN</chem>	<chem>CCO</chem>	15	<chem>CC[O-]</chem>	
	Ammonium (alkyle)		Amine (alkyle)	Alcool		Alcoolate	
	<chem>c1ccccc1[NH3+]</chem>	5	<chem>c1ccccc1N</chem>	<chem>c1ccccc1O</chem>	10	<chem>c1ccccc1[O-]</chem>	
	Ammonium (aryle)		Amine (aryle)	Phénol		Phénolate	
	<chem>CC(=O)[NH3+]</chem>	<1	<chem>CC(=O)N</chem>	<chem>CC(=O)O</chem>	5	<chem>CC(=O)[O-]</chem>	
	Acide fort		Amide	Acide carboxylique		Carboxylate	
				<chem>c1ccccc1C(=O)O</chem>	5	<chem>c1ccccc1C(=O)[O-]</chem>	
				Acide benzoïque		Bénzoate	
				<chem>CC[OH2+]</chem>	<1	<chem>CCO</chem>	Base conjuguée faible
				Alcool			

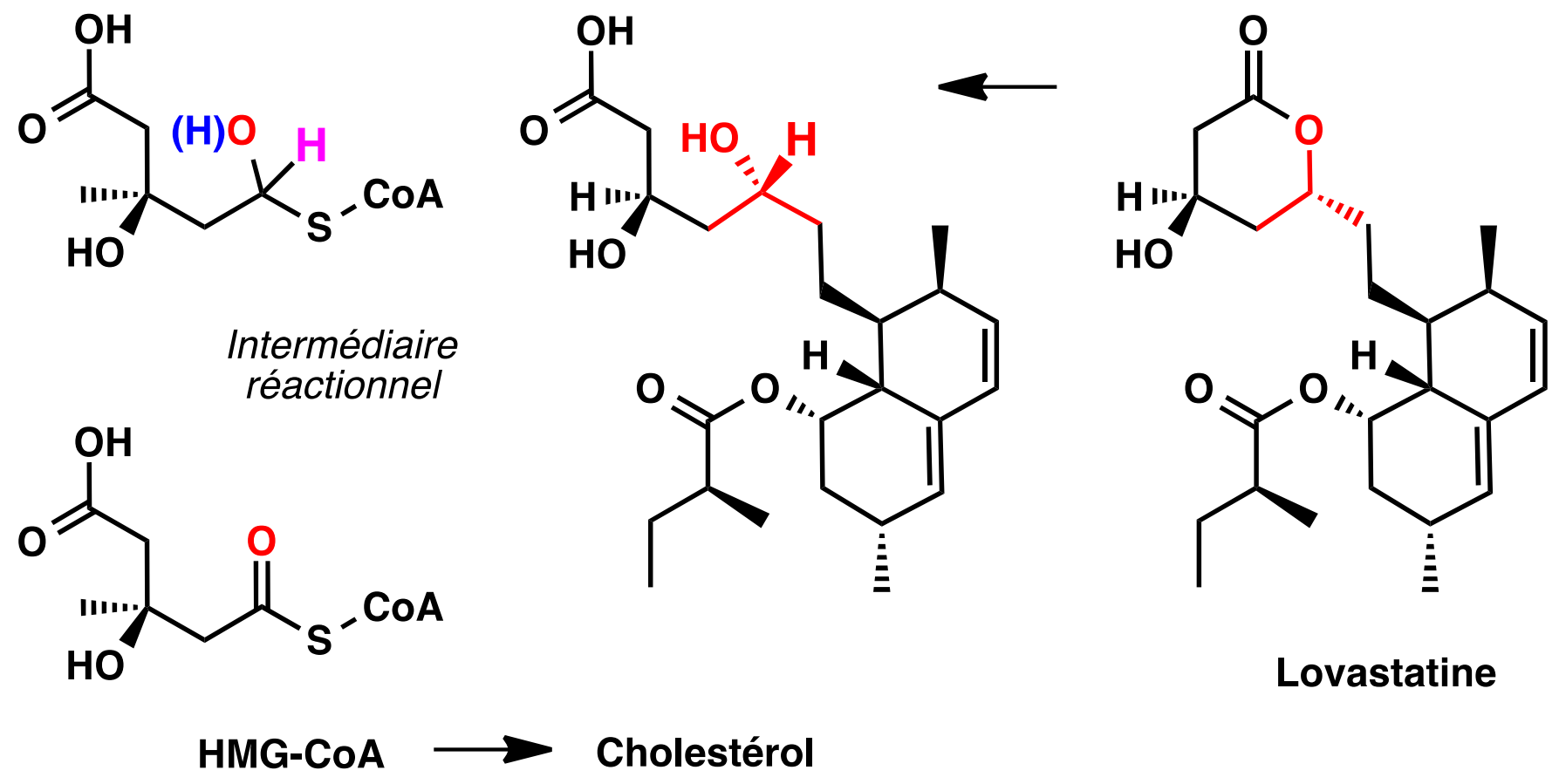
pK_a

Acide faible

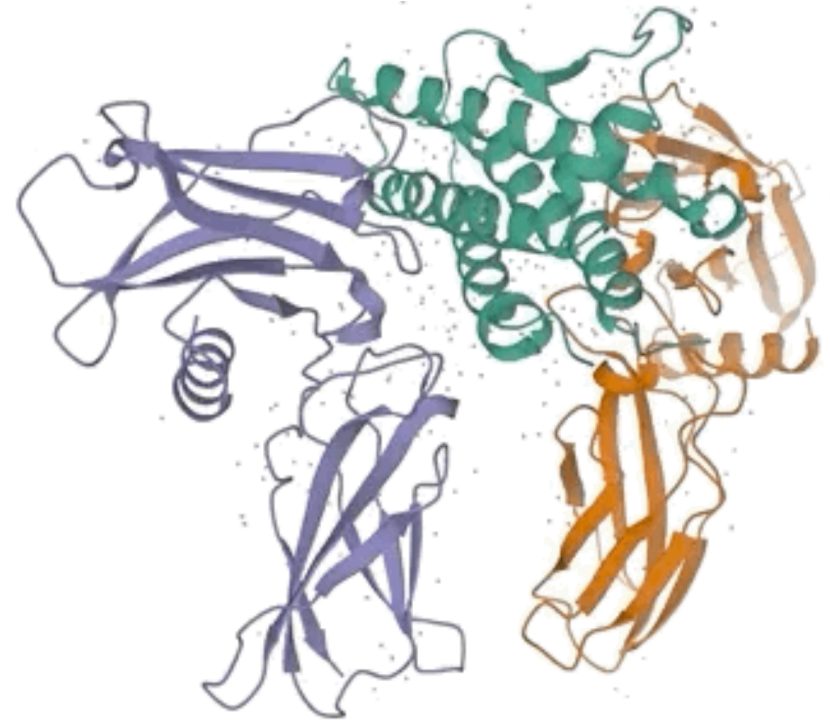
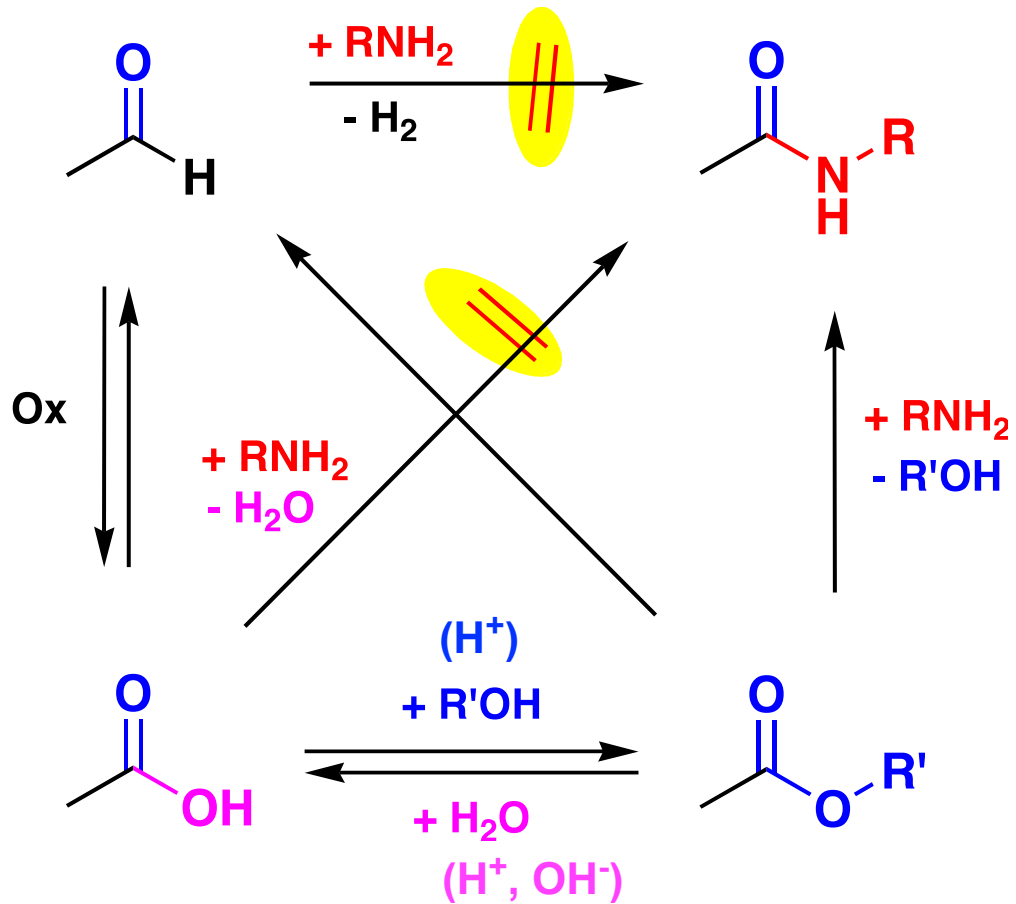
Acide fort



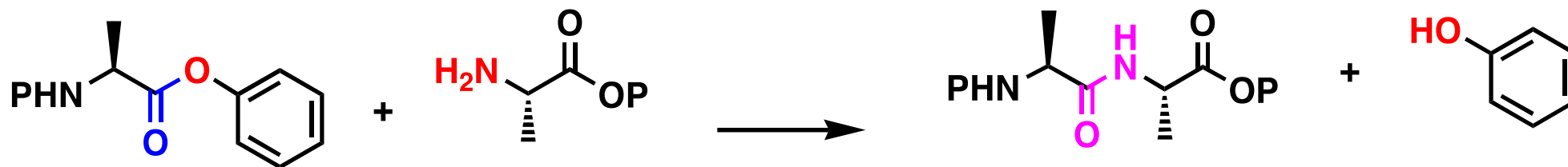
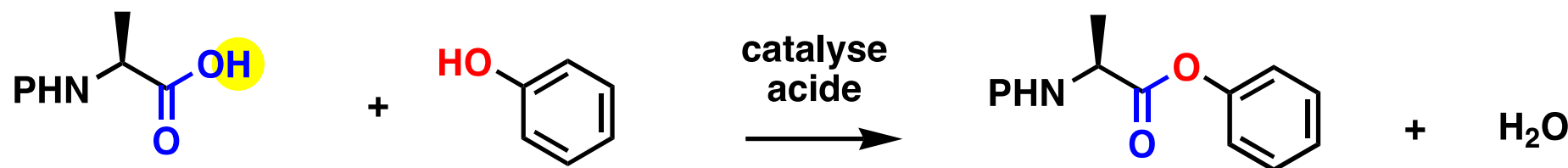
Hydrolyse des lactones (médicaments anti-cholestérol)



Synthèse des protéines

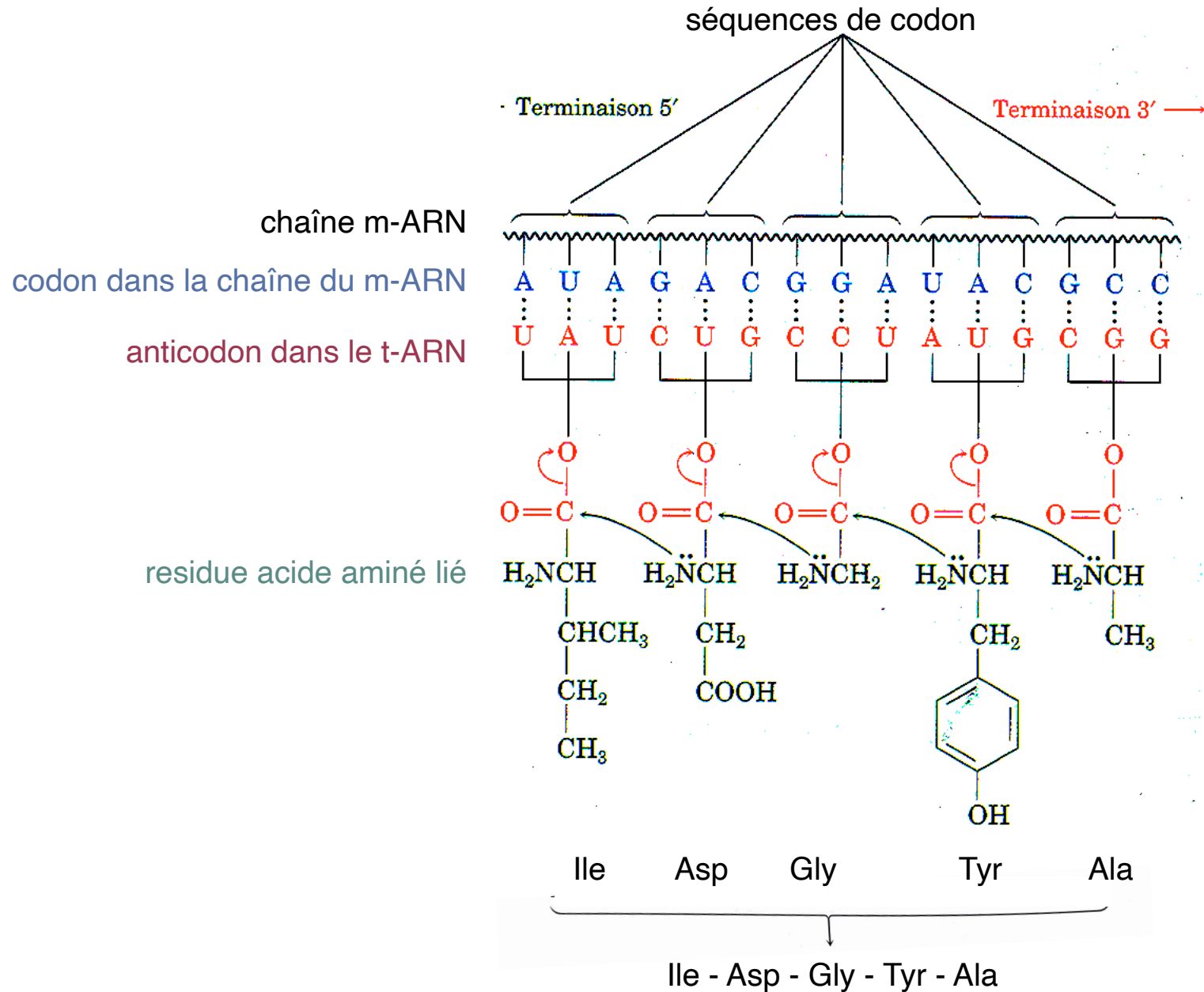


Synthèse des protéines

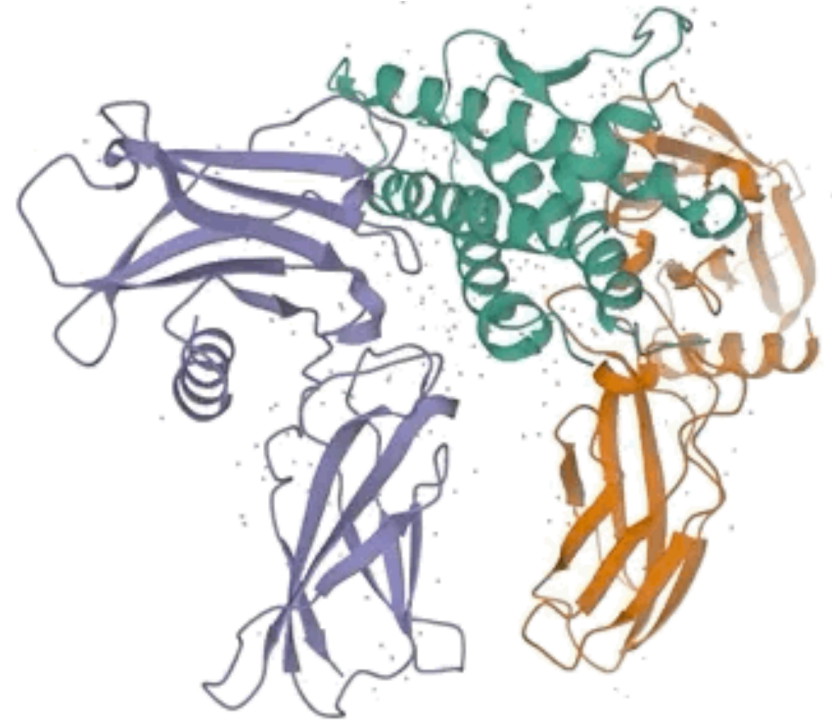
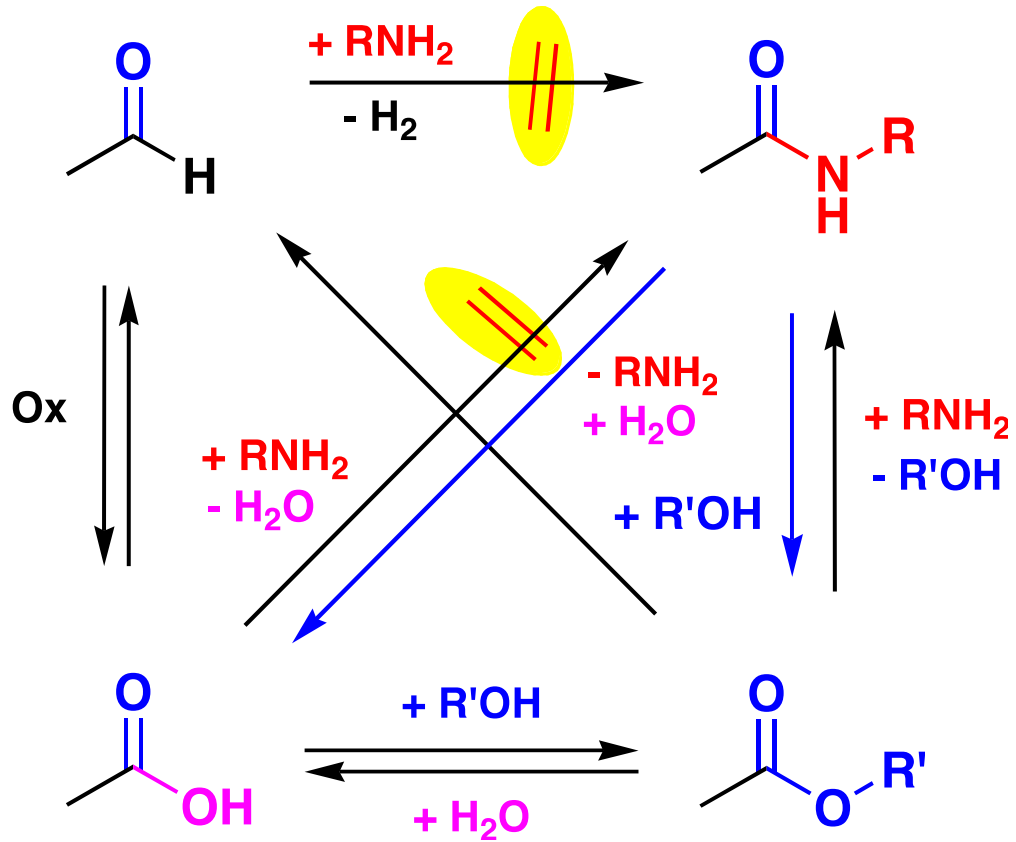


P groupe protecteur

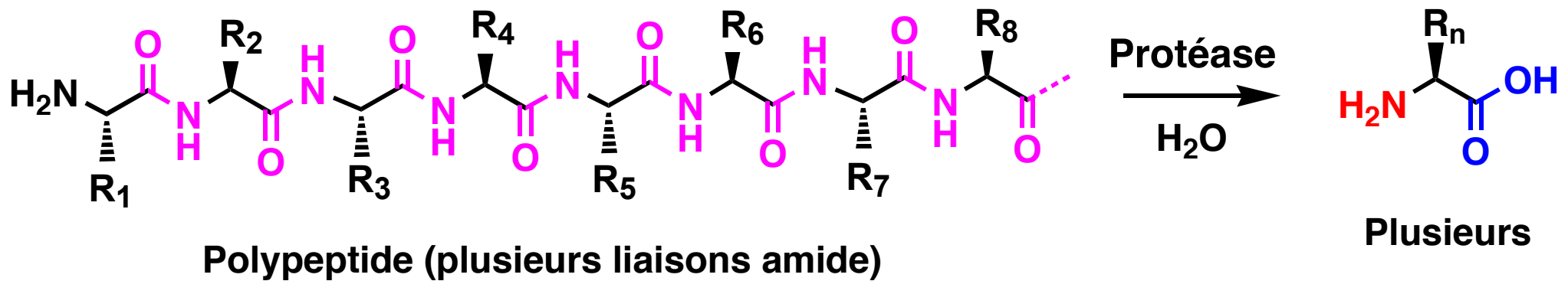
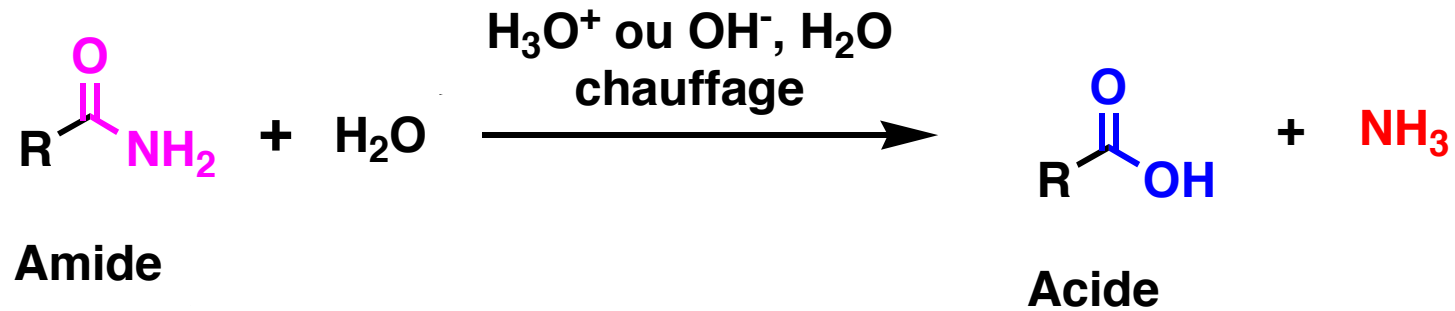
Synthèse des protéines



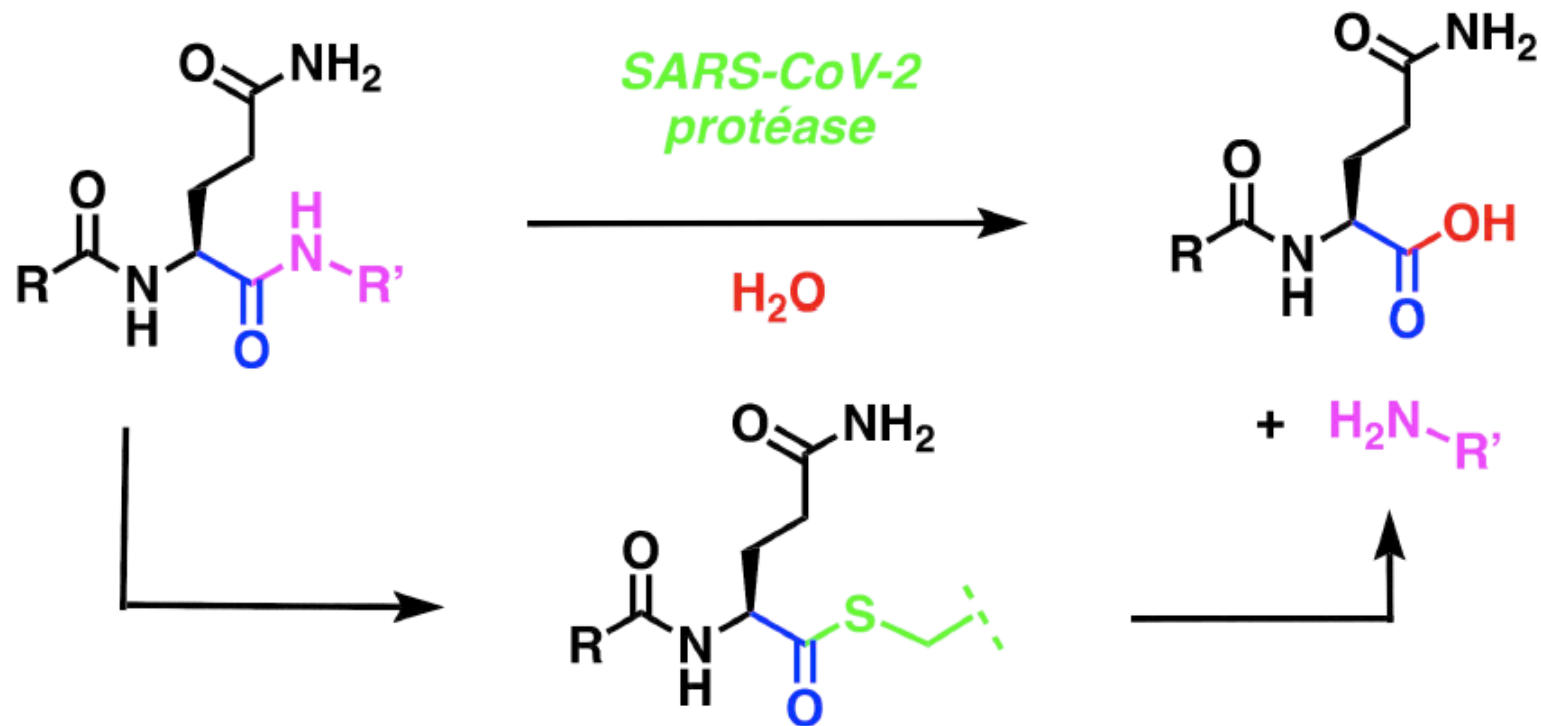
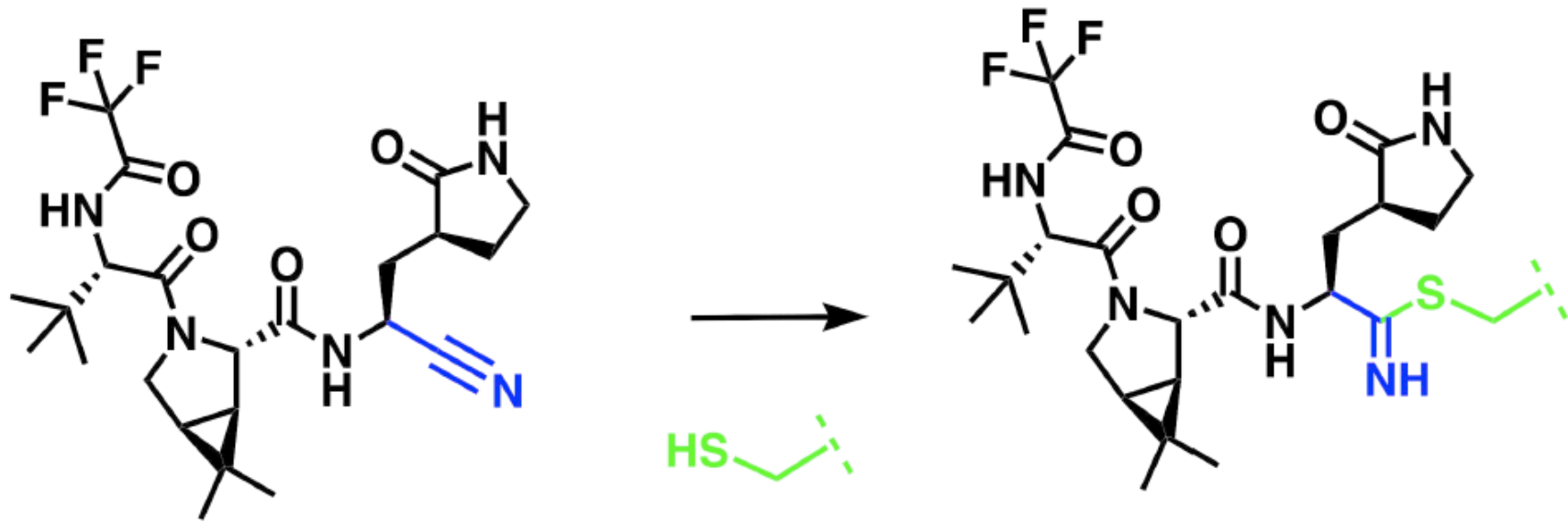
Synthèse des protéines



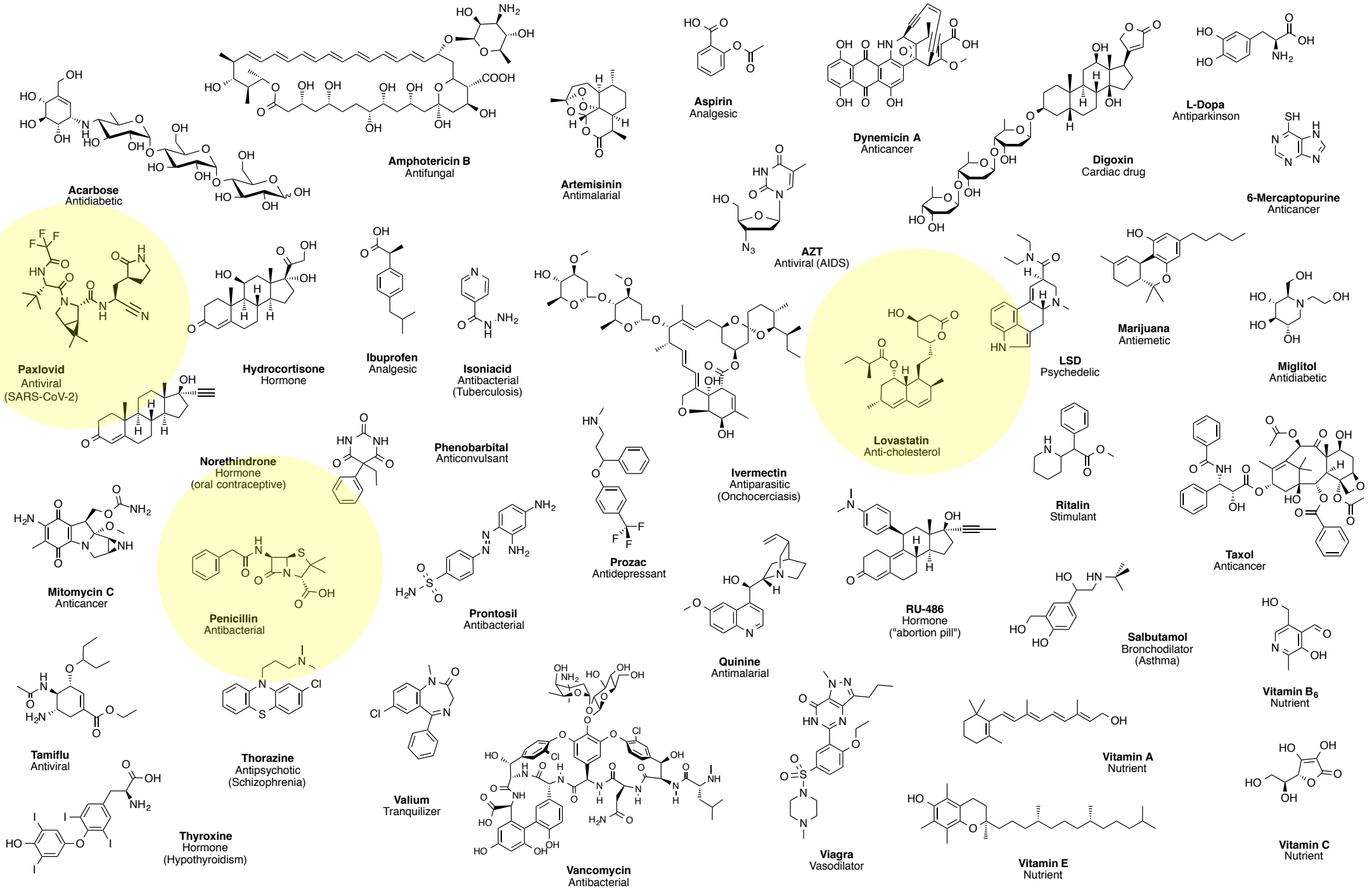
Hydrolyse des amides - enzymes

















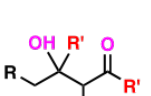



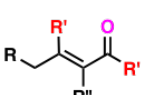


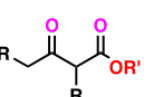


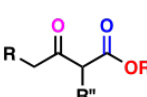
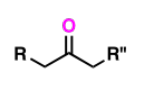











Paxlovid



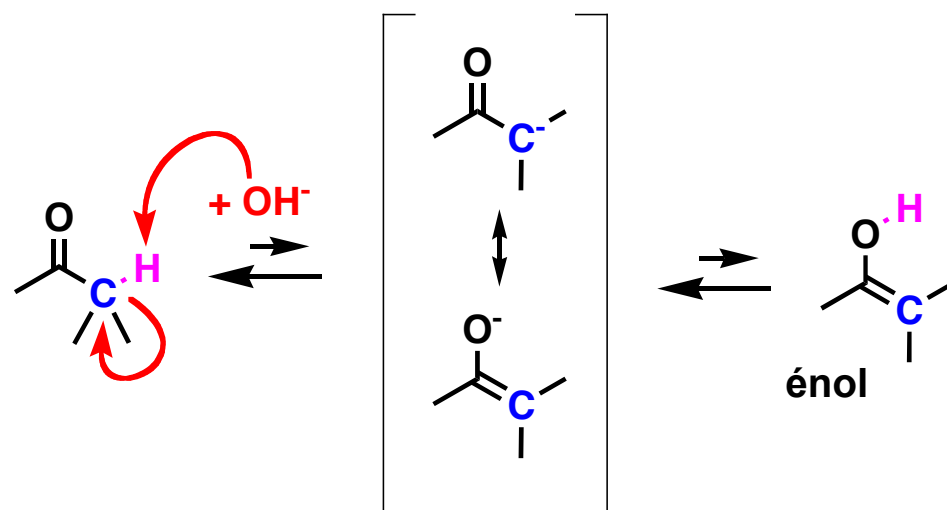
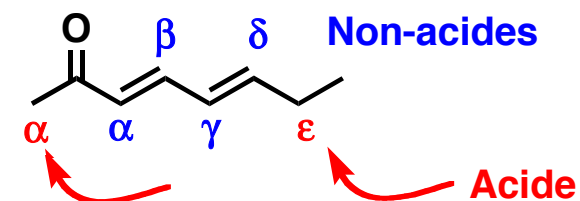
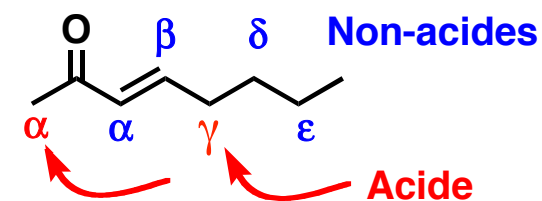
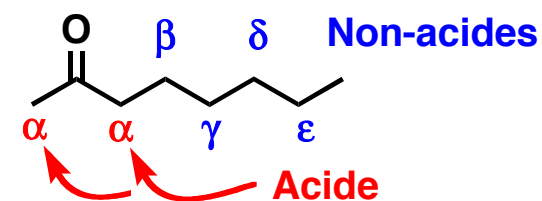
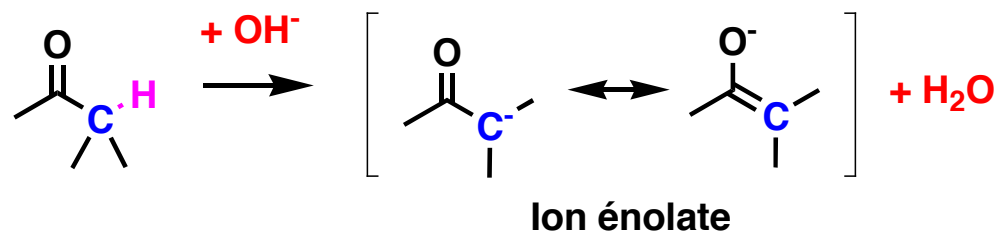
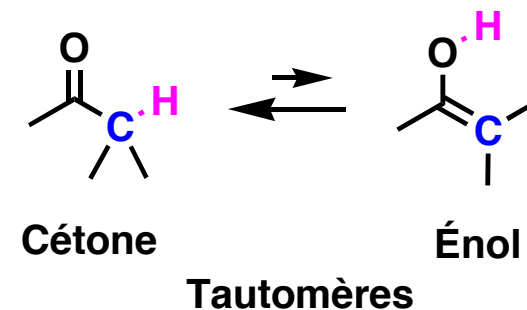
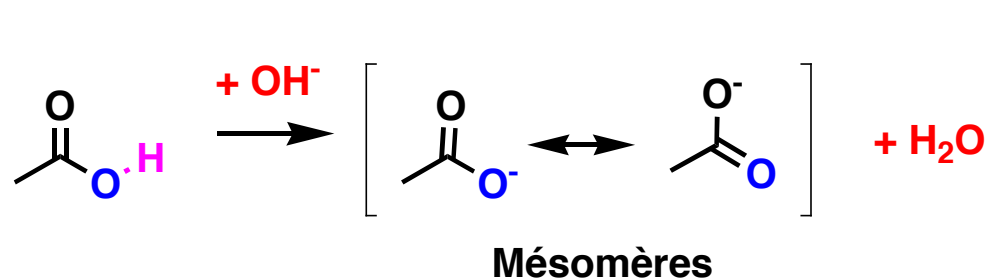
Molécules qui ont changé notre monde...



Résumé des réactions

										2007	2003
	$\xrightarrow{\text{H}_2, \text{catalyseur}}$		4.6	4.6		+ ROH	$\xrightleftharpoons[\text{Catalyseur (OH}^- \text{ ou H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		+ H ₂ O	10.8	10.6
Alcène		Alcane			Acide carboxylique	Alcool		Ester		10.11	10.9
	$\xrightleftharpoons[\text{LiAlH}_4, \text{ puis H}_3\text{O}^+]{\text{CrO}_3, \text{ H}_3\text{O}^+}$		8.5	8.7		+ R'NH ₂	$\xrightleftharpoons[\text{Chauffage, catalyseur (OH}^- \text{ ou H}_3\text{O}^+)]{\text{Chauffage, catalyseur (OH}^- \text{ ou H}_3\text{O}^+)}$		+ ROH	16.13	10.9
Alcool primaire		Acide carboxylique			Ester	Amine		Amide	Alcool	10.10	10.10
	$\xrightleftharpoons[\text{NaBH}_4, \text{ puis H}_3\text{O}^+]{\text{Na}_2\text{Cr}_2\text{O}_7, \text{ H}_3\text{O}^+}$		8.5	8.7			$\xrightarrow{\text{LiAlH}_4, \text{ puis H}_3\text{O}^+}$		+ ROH	10.11	10.9
Alcool secondaire		Cétone			Ester			Alcool primaire	Alcool	8.4	8.5
	$\xrightleftharpoons[\text{NaBH}_4, \text{ puis H}_3\text{O}^+]{\text{PCC}}$		8.5	8.7	$2 \text{ R-CH}_2\text{-C(=O)-R}'$		$\xrightleftharpoons[\text{Catalyseur (OH}^-)]{\text{Catalyseur (OH}^-)}$			11.9	11.8
Alcool primaire		Aldéhyde			Aldéhyde / cétone			β-Hydroxycétone			
	$\xrightarrow{\text{Na}_2\text{Cr}_2\text{O}_7, \text{ H}_3\text{O}^+}$		8.6	8.8			$\xrightarrow{\text{Catalyseur (OH}^- \text{ ou H}_3\text{O}^+)}$		+ H ₂ O	11.10	11.9
Phénol		Benzoquinone			β-Hydroxycétone			Énone conjuguée			
	$\xrightleftharpoons[\text{NaBH}_4, \text{ puis H}_3\text{O}^+]{\text{Na}_2\text{Cr}_2\text{O}_7, \text{ H}_3\text{O}^+}$		8.6	8.8	$2 \text{ R-CH}_2\text{-C(=O)-OR}'$		$\xrightleftharpoons[\text{Catalyseur (NaOR}^')]{\text{Catalyseur (NaOR}^')}$		+ R'OH	11.11	11.10
Hydroquinone		Benzoquinone			Ester			β-Cétoester	Alcool		
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.7	9.7			$\xrightarrow{\text{Chauffage, catalyseur (OH}^- \text{ ou H}_3\text{O}^+)}$		+ R'OH + CO ₂	17.4	17.4
Aldéhyde / cétone		Hydrate			β-Cétoester			Cétone			
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.8	9.8	$\text{RNH}_2 + \text{R}''\text{-CH}_2\text{-CH(OH)-GP}$		$\xrightarrow{\text{NaCNBH}_3, \text{ puis H}_3\text{O}^+}$		+ HGP ⁺	12.4	12.4
Aldéhyde / cétone		Hémiacétal			Amine	GP = groupe partant		Alkylamine		7.5	7.7
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.9	14.5						9.10	9.11
Aldéhyde / cétone		Acétal		14.6	Imine			Amine			
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.8	9.8							
Aldéhyde / cétone		Acétal		14.7							
	$\xrightleftharpoons[\text{Catalyseur (H}_3\text{O}^+)]{\text{Catalyseur (H}_3\text{O}^+)}$		9.9	14.8							
Aldéhyde / cétone		Acétal		14.8							

Tautomérie céto-énolique



conjugaison

Tautomères

A

Alternance de liaisons simples et multiples avec recouvrement des orbitales p

B

Anion d'un enol ; carbanion alpha-cétonique stabilisé par résonance

C

Représentations d'une molécule ne différant que par la position des électrons de liaison

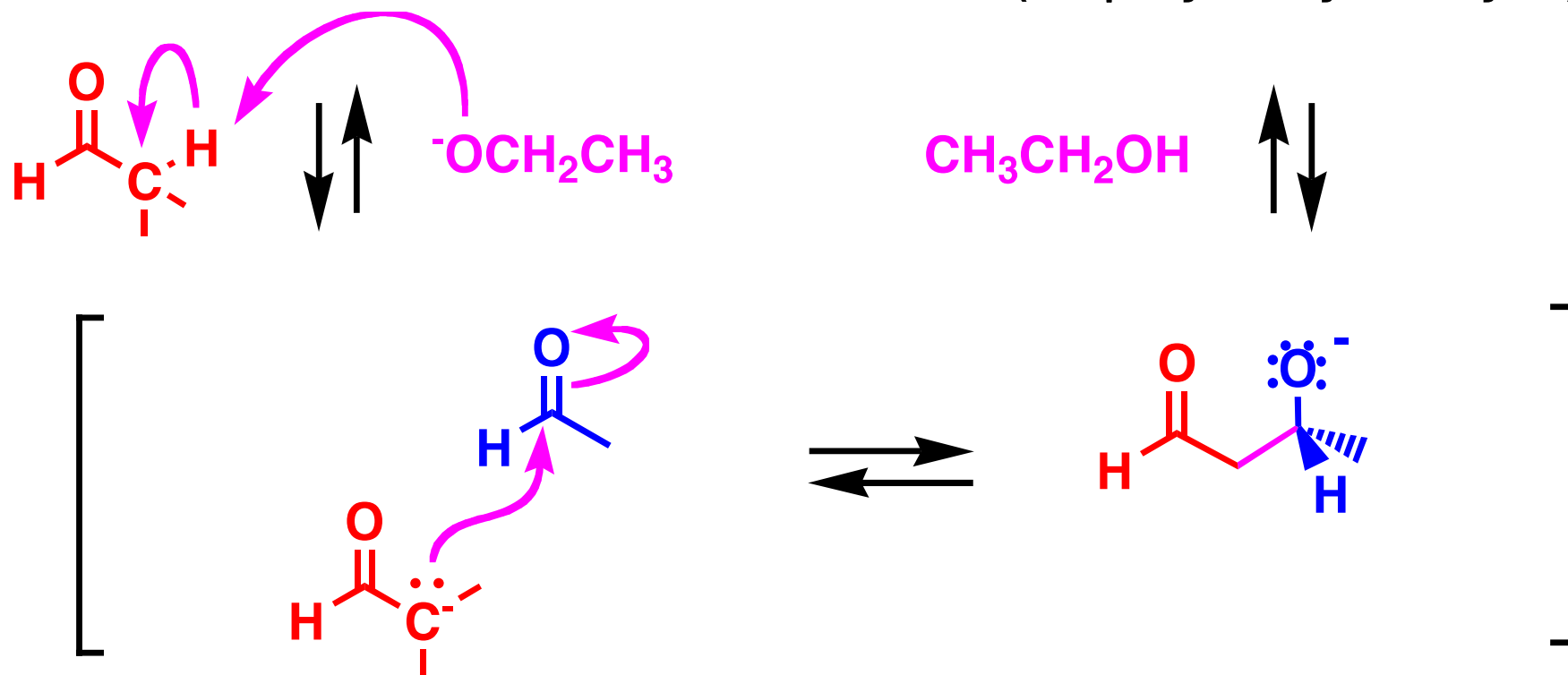
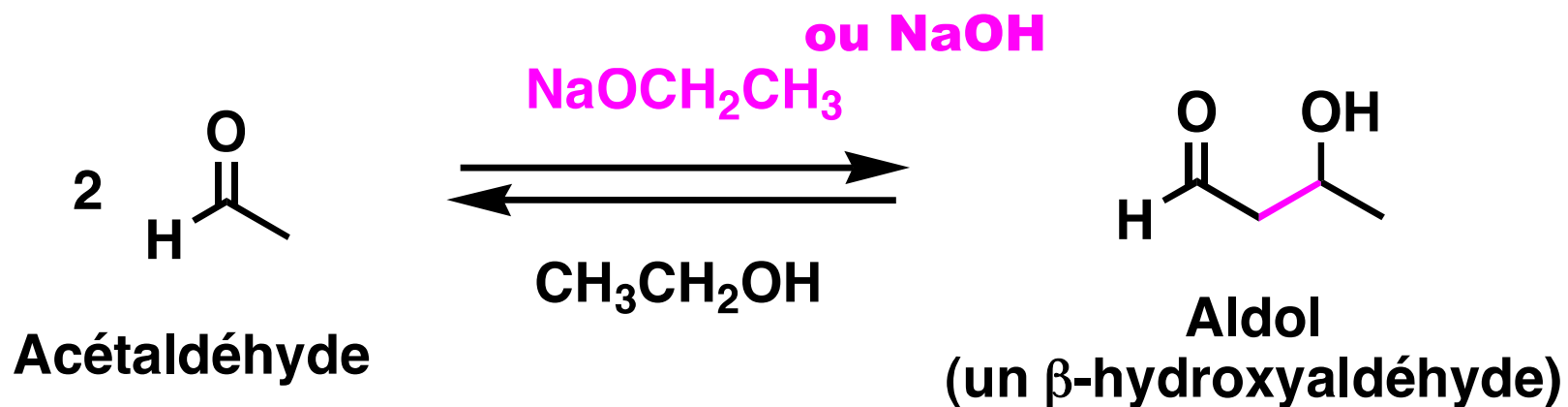
D

molécules avec même formule moléculaire, mais d'arrangements des atomes différents

E

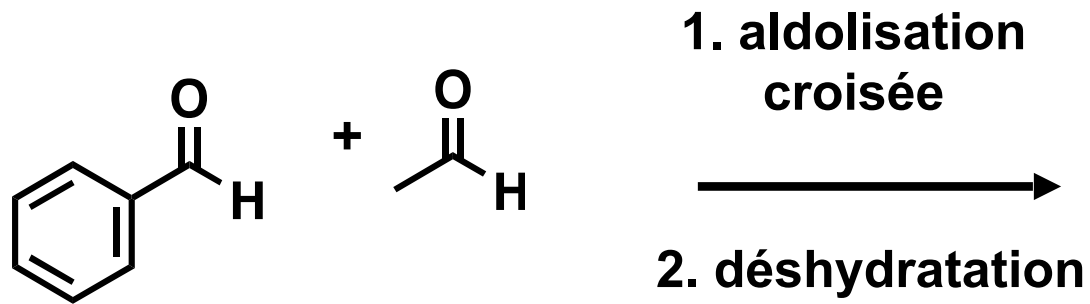
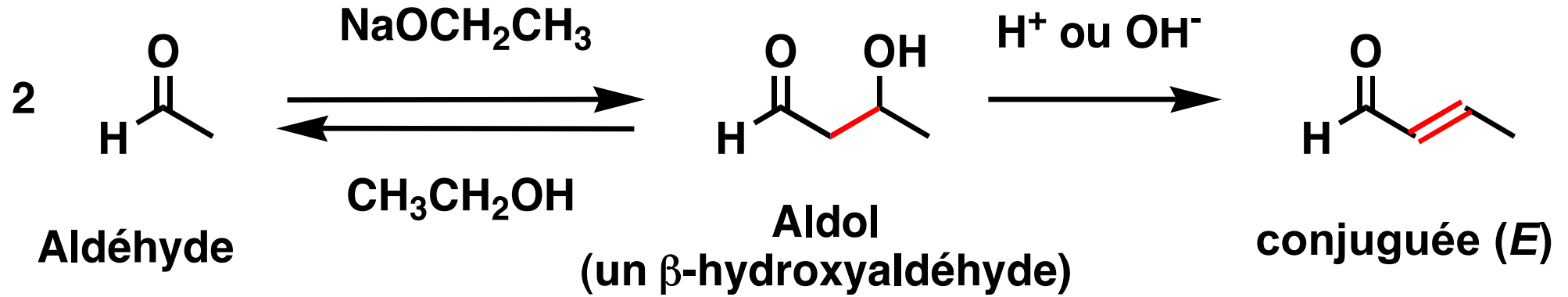
Isomères qui s'interconvertissent rapidement

L'aldolisation

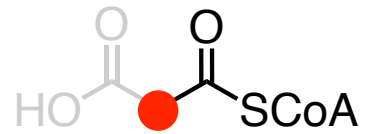


addition nucléophile

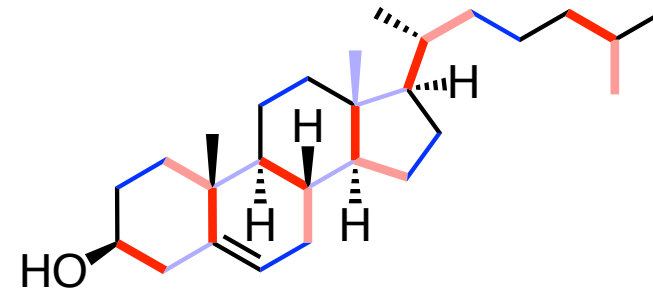
Déshydratation



Condensation de Claisen

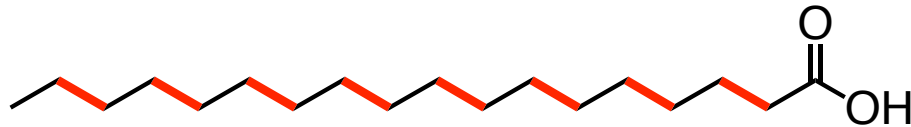


Aldolisation Condensation de Claisen



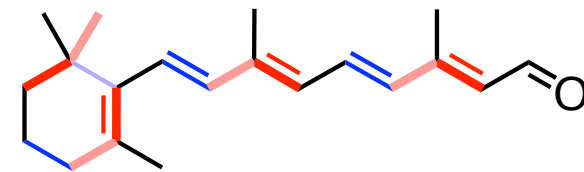
Cholestérol

52%



Acide stéarique

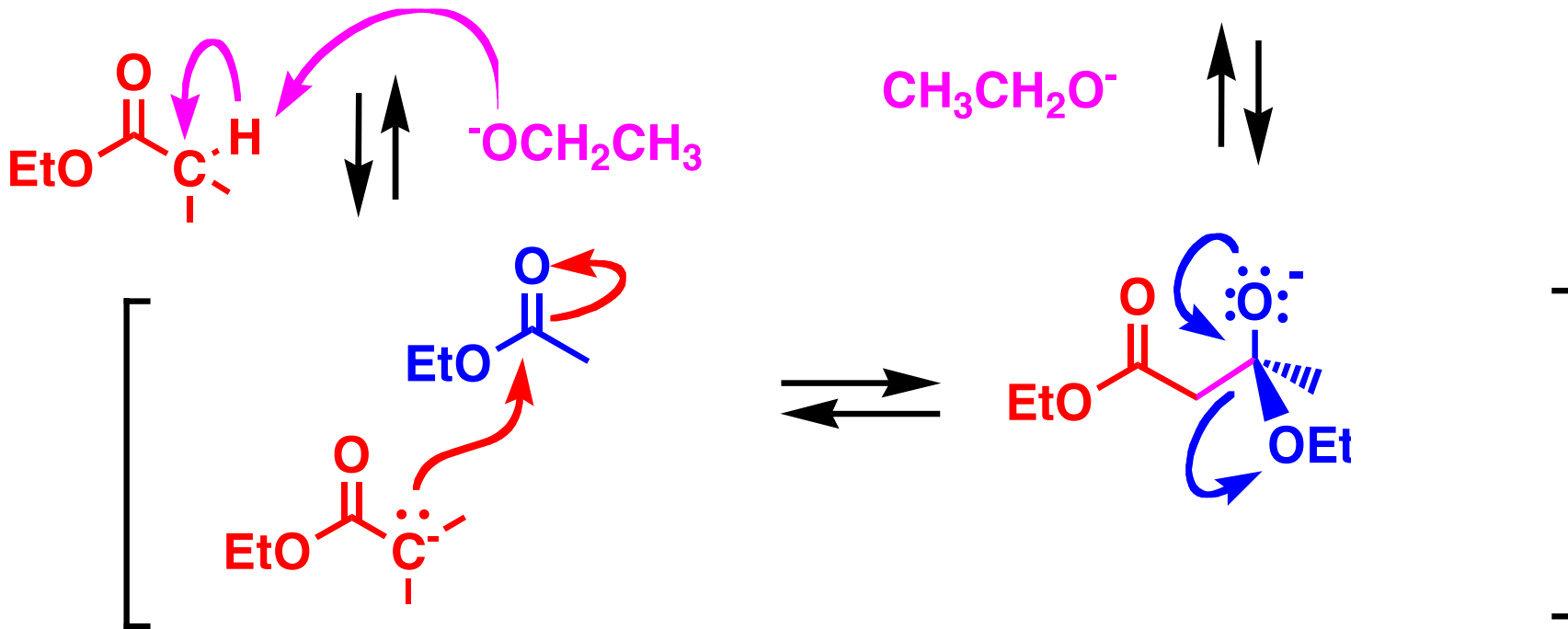
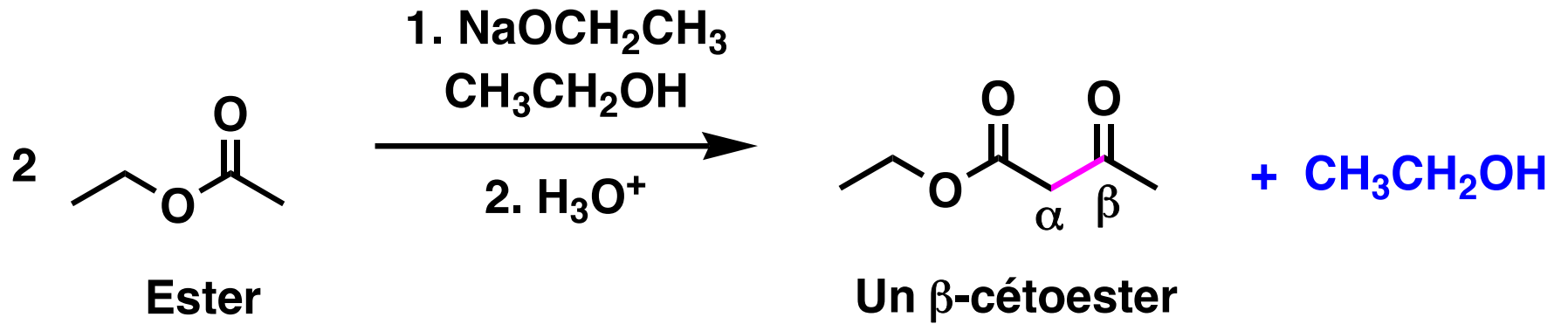
100%



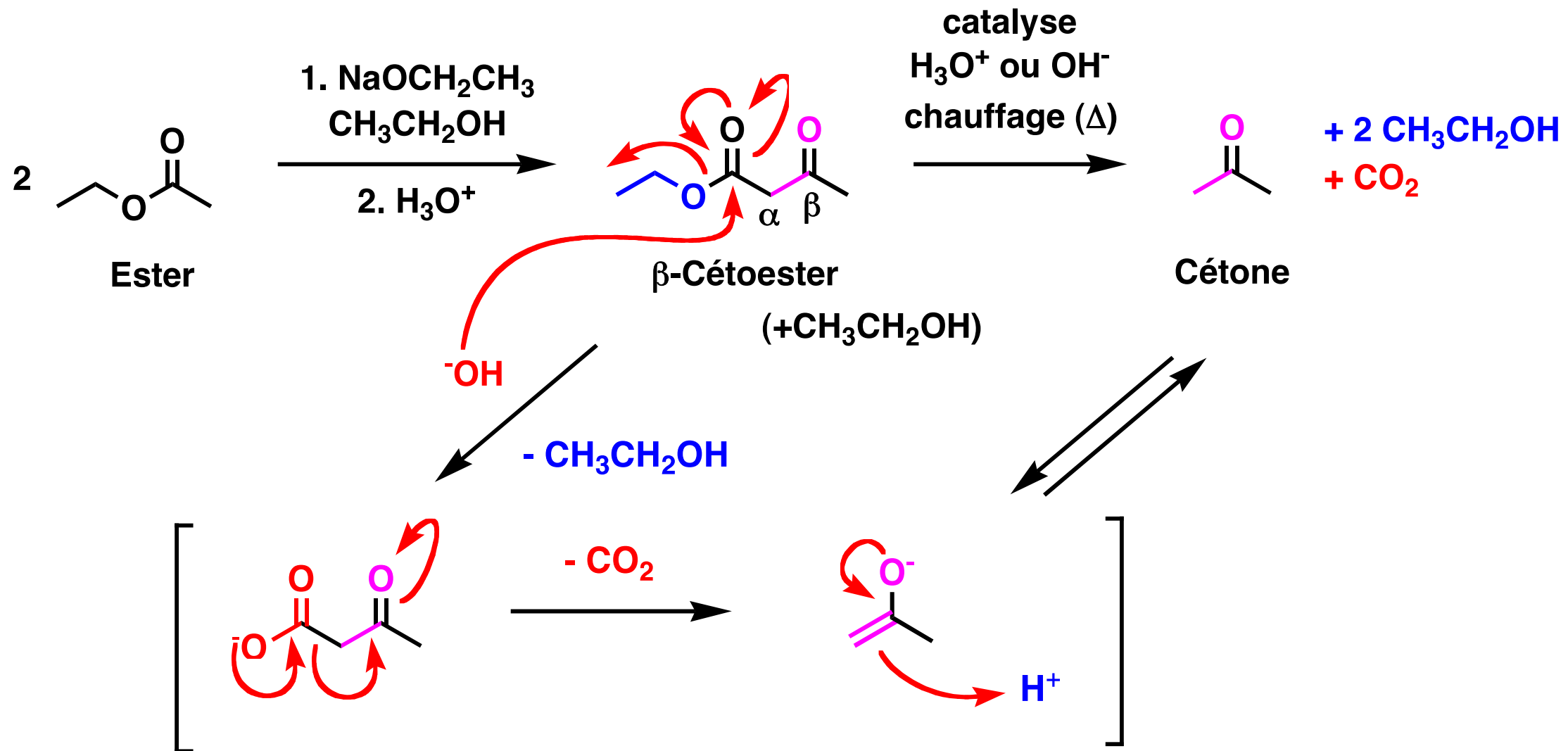
Rétinal

67%

Condensation de Claisen



Décarboxylation



Résumé 6 (Acides - Esters - Amides - Protéines -)

- **synthèse et dégradation des protéines, liaisons C-C, médicaments**
- **acides et bases : acidité et résonance (alcools - acides) - énolate**
- **tautomère (enol) / mésomère / conjugaison / chiralité**
- **substitution (addition) nucléophile :**
 - **acide + alcool : ester + H₂O (Fischer, catalyse acide)**
 - **ester + H₂O : acide + alcool (saponification ; thioester : thiol; lactone, médicaments)**
 - **ester + amine : amide + alcool (protéines ; acide + amine : x)**
 - **amide + H₂O : acide + amine (médicaments ; alcool : ester ; lactame, médicaments)**
 - **réduction ester / acide : alcool primaire (thioester : thiol, médicaments)**
 - **2 x aldéhyde / cétone : aldol (aldolisation) / énone conjuguée (déshydratation)**
 - **2 x ester : β-cétoester (condensation de Claisen) / cétone (décarboxylation)**

CONTENU

McMurry

1. Généralités

(1, 2, 15)

2. Lipides - stéroïdes - alcanes -

(2 - 5, 16)

alcènes - arènes -

3. Glucides - stéréochimie -

(6, 14)

4. Alcools - éthers - phénols -

(8, 16)

hydroquinones - thiols - disulfures

5. Glucides - aldéhydes - cétones -

(9, 14)

imines -

6. Protéines - lipides -

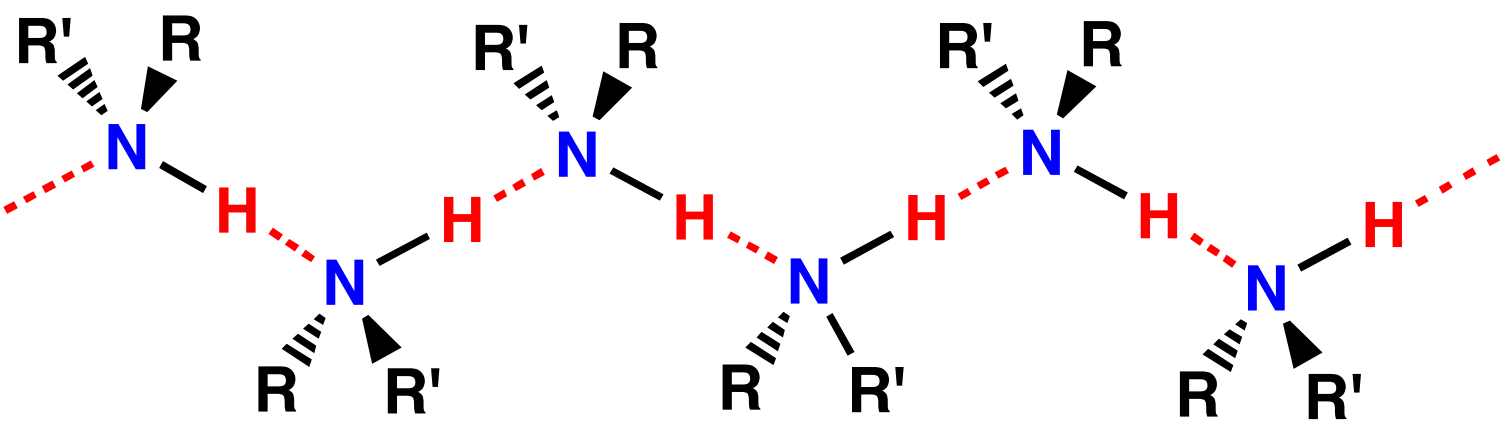
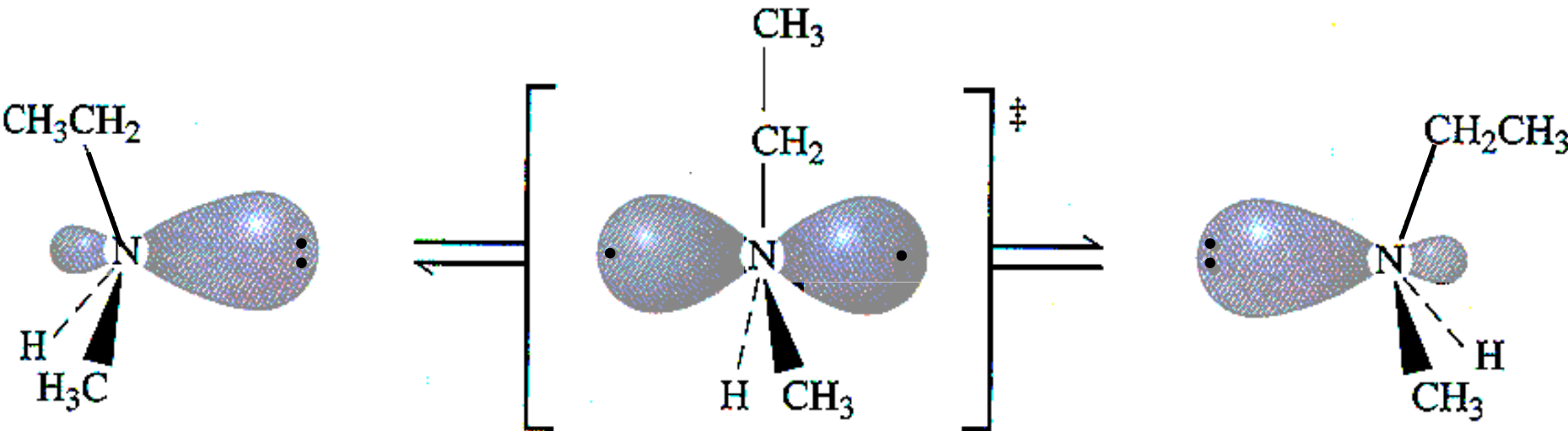
(10, 11, 15, 16)

acides - esters - amides -

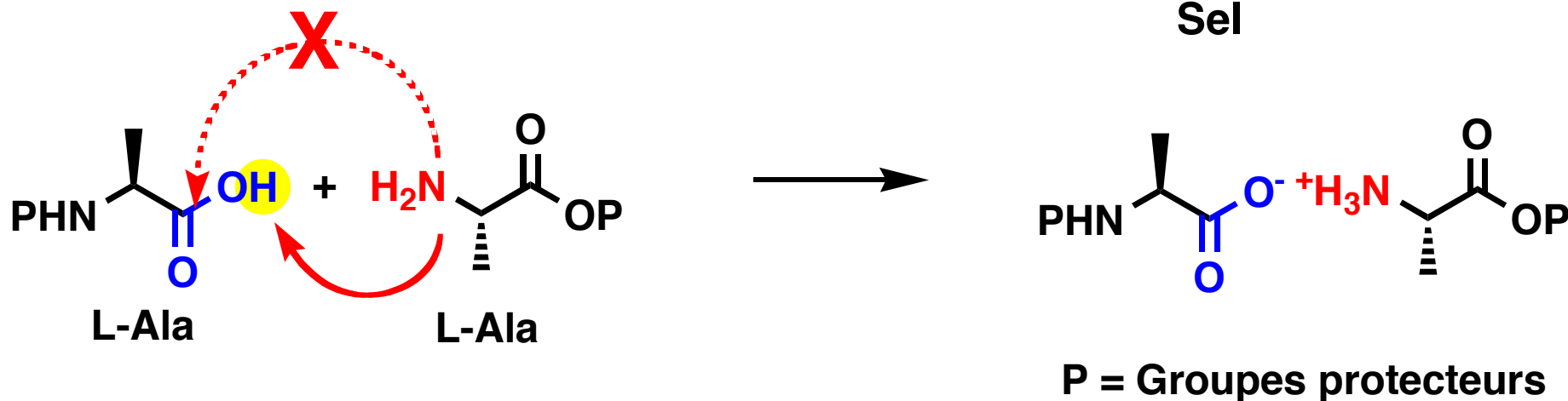
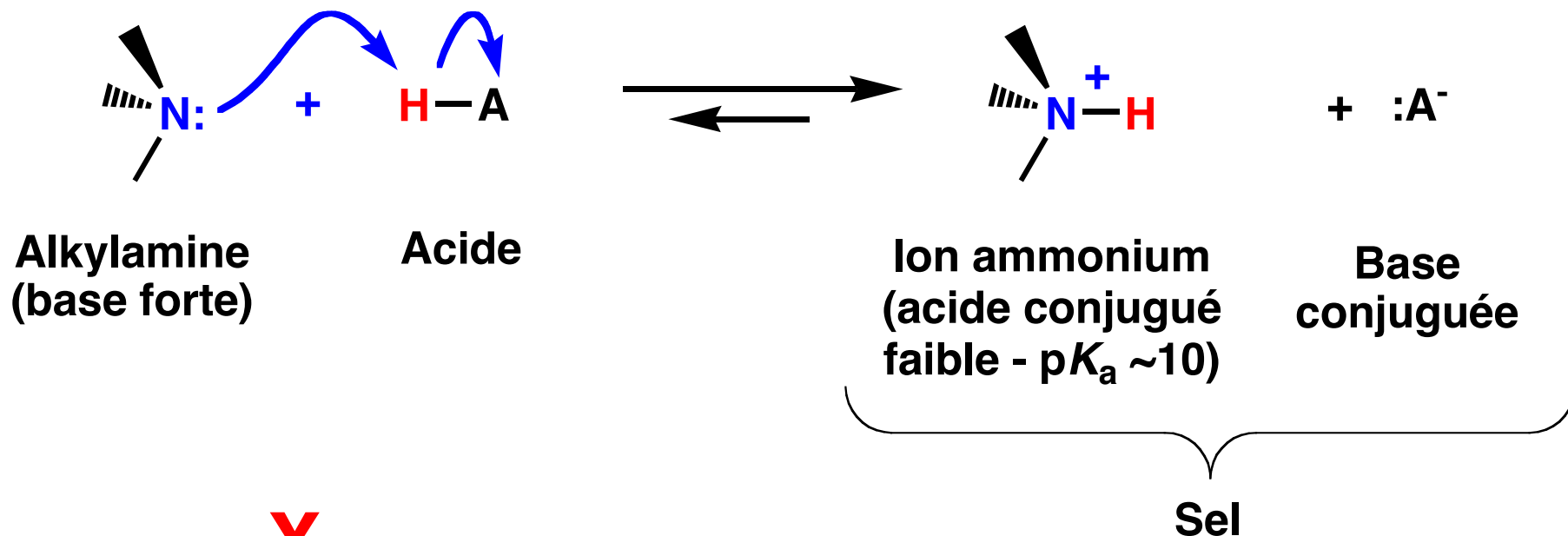
7. Acides nucléiques - amines -

(12, 16)

« L'azote sp^3 »



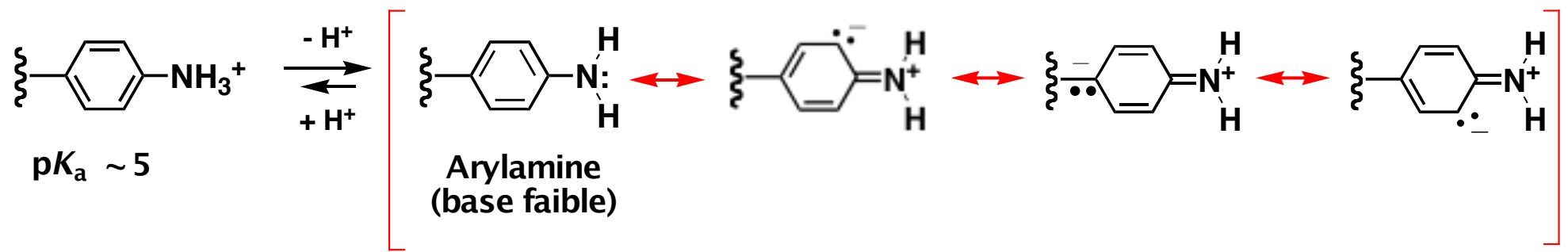
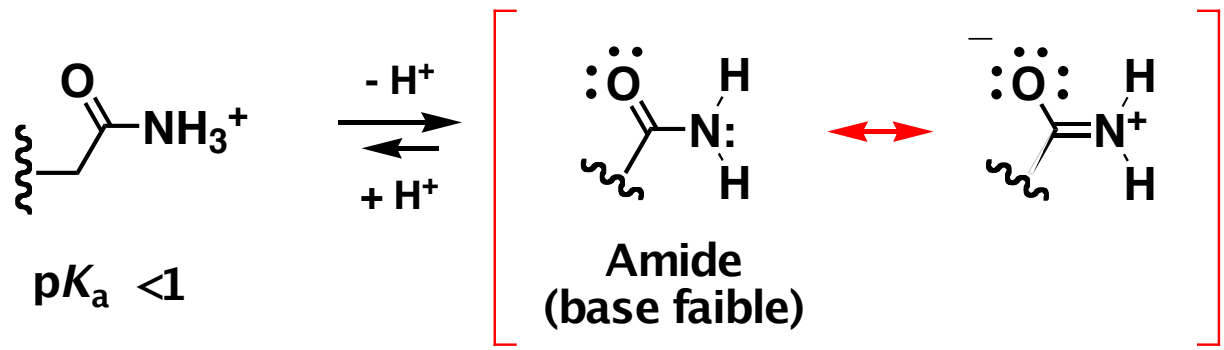
« L'azote sp^3 »



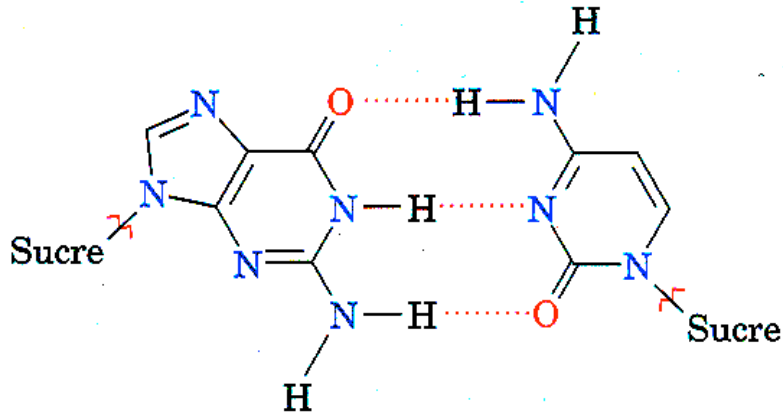
Résumé acides et bases

	Acide	pK _a	Base conjuguée	Acide	pK _a	Base conjuguée	
	<chem>CCN</chem>	>25	<chem>CC[NH-]</chem>	<chem>CCC</chem>	>25	<chem>CC[CH-]</chem>	Base conjuguée forte
	Amine (alkyle)			Alcane			
	<chem>CC(=O)N</chem>	>25	<chem>CC(=O)[NH-]</chem>	<chem>CCC(=O)C</chem>	20	<chem>CCC(=O)[O-]</chem>	
	Amide			Cétone (Aldehyde, Ester)		Énolate	
Acide faible	<chem>CC[NH3+]</chem>	10	<chem>CCN</chem>	<chem>CCO</chem>	15	<chem>CC[O-]</chem>	
	Ammonium (alkyle)		Amine (alkyle)	Alcool		Alcoolate	
	<chem>c1ccccc1[NH3+]</chem>	5	<chem>c1ccccc1N</chem>	<chem>c1ccccc1O</chem>	10	<chem>c1ccccc1[O-]</chem>	
	Ammonium (aryle)		Amine (aryle)	Phénol		Phénolate	
Acide fort	<chem>CC(=O)[NH3+]</chem>	<1	<chem>CC(=O)N</chem>	<chem>CC(=O)O</chem>	5	<chem>CC(=O)[O-]</chem>	
			Amide	Acide carboxylique		Carboxylate	
				<chem>c1ccccc1C(=O)O</chem>	5	<chem>c1ccccc1C(=O)[O-]</chem>	
			Acide benzoïque		Benzoate		
	<chem>CC[OH2+]</chem>	<1	<chem>CCO</chem>				Base conjuguée faible
			Alcool				

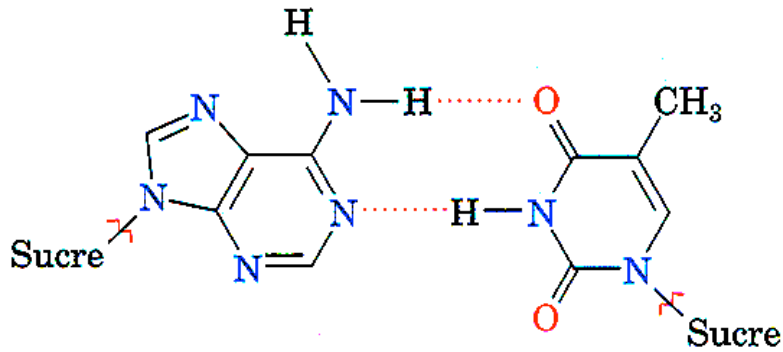
« L'azote sp² »



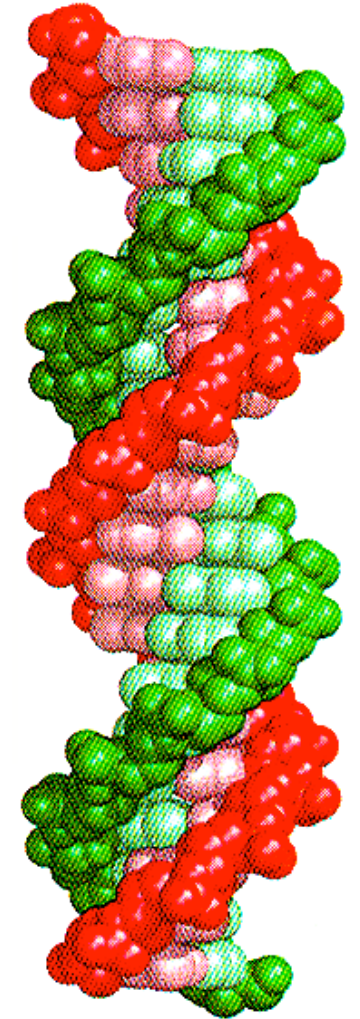
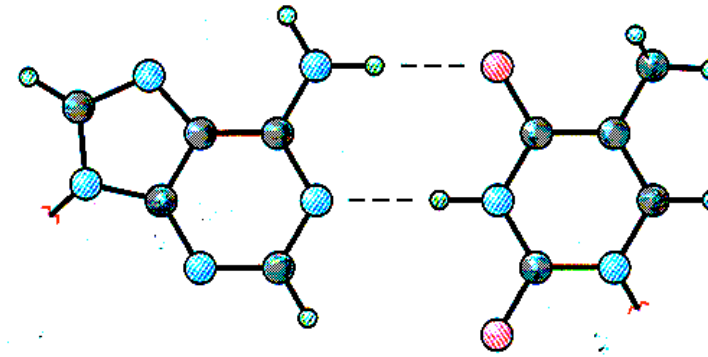
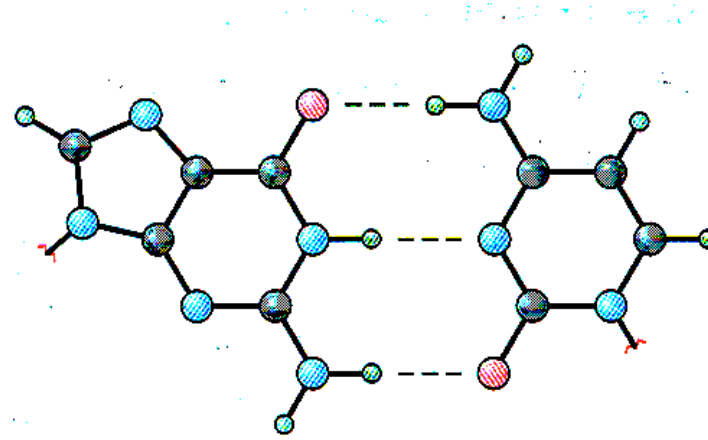
Arylamines et le code génétique



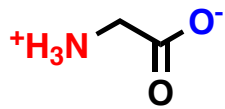
(Guanine) G ::::: C (Cytosine)



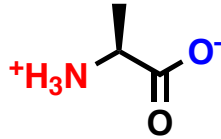
(Adénine) A ::::: T (Thymine)



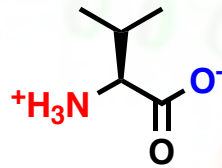
Les acides aminés (pH = 7)



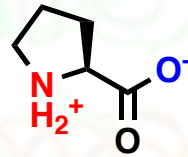
Glycine
(Gly, G)



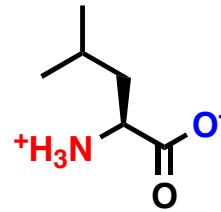
Alanine
(Ala, A)



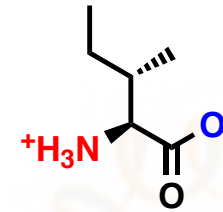
Valine
(Val, V)



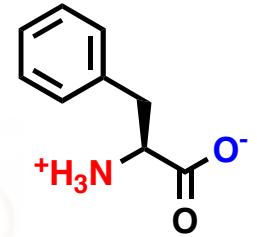
Proline
(Pro, P)



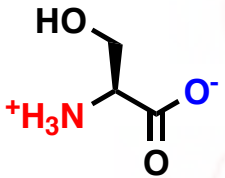
Leucine
(Leu, L)



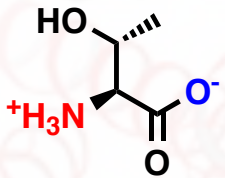
Isoleucine
(Ile, I)



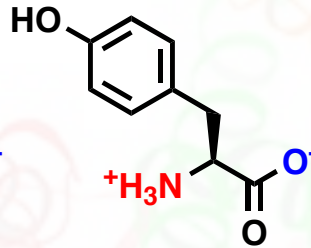
Phénylalanine
(Phe, F)



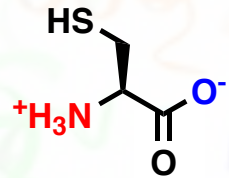
Sérine
(Ser, S)



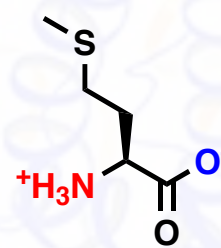
Thréonine
(Thr, T)



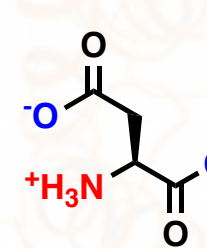
Tyrosine
(Tyr, Y)



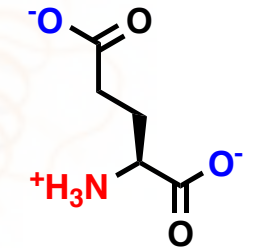
Cystéine
(Cys, C)



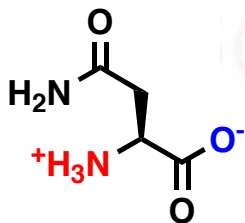
Méthionine
(Met, M)



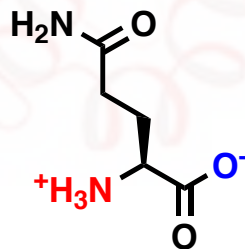
Acide aspartique
(Asp, D)



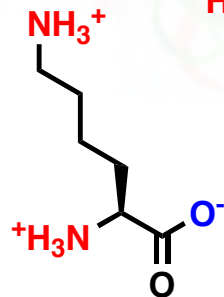
Acide glutamique
(Glu, E)



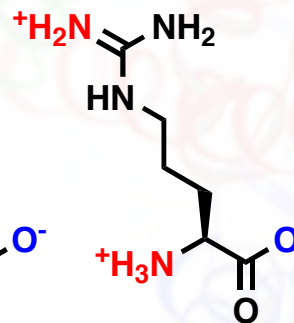
Asparagine
(Asn, N)



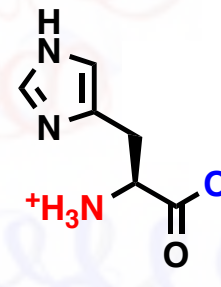
Glutamine
(Gln, Q)



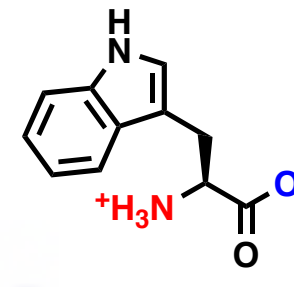
Lysine
(Lys, K)



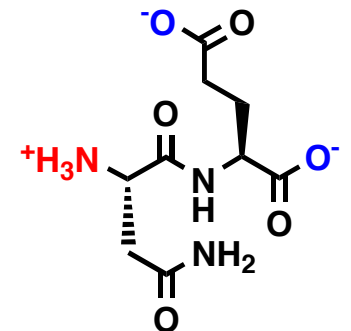
Arginine
(Arg, R)



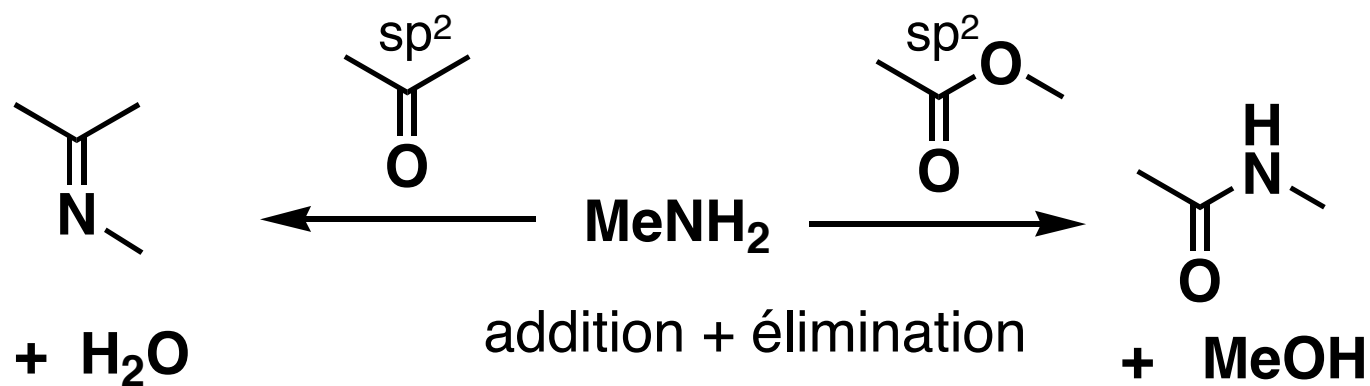
Histidine
(His, H)

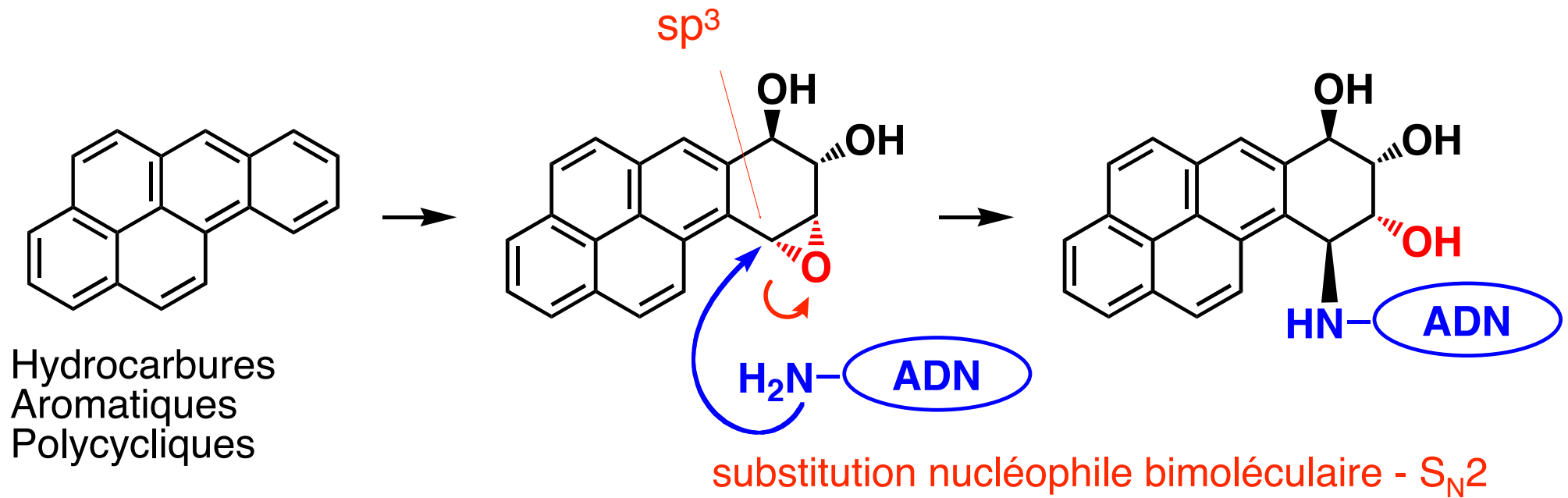


Tryptophane
(Trp, W)

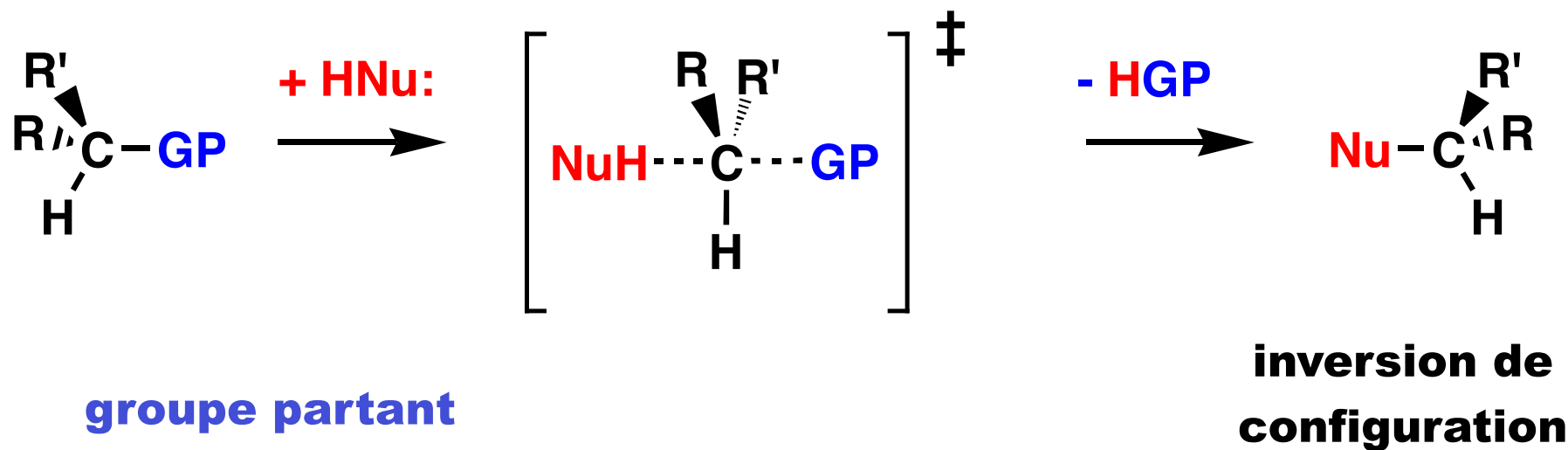
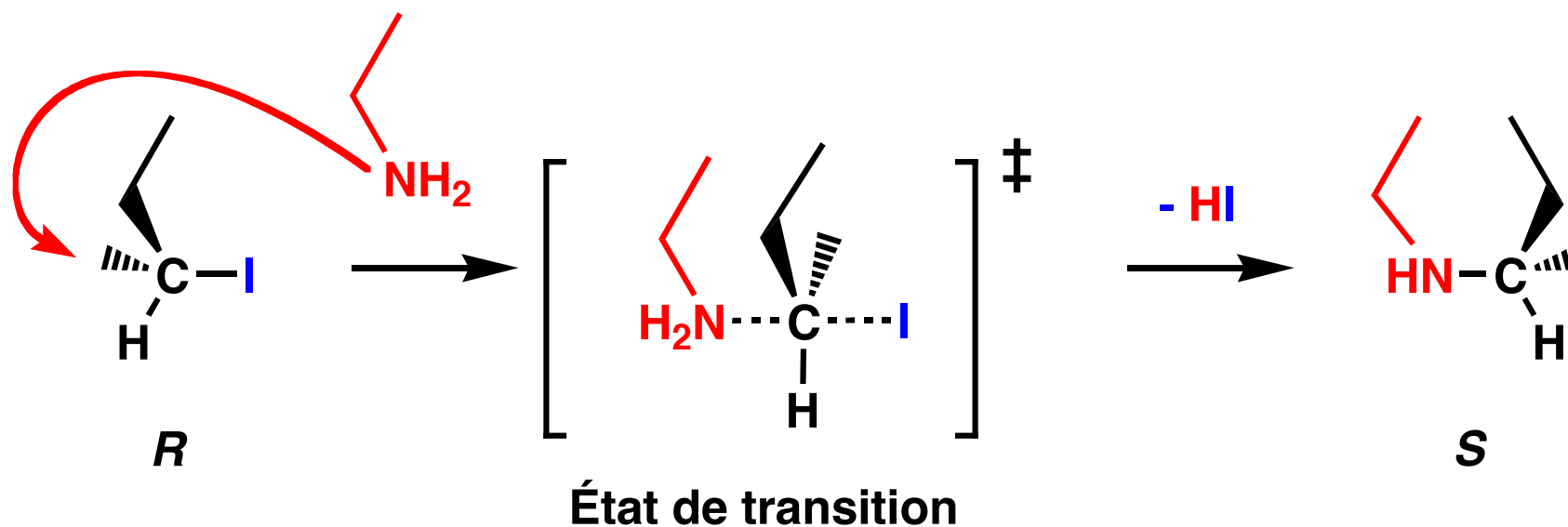


Nucléophile

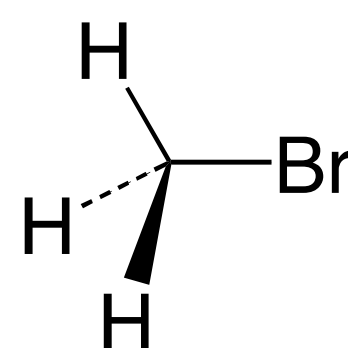
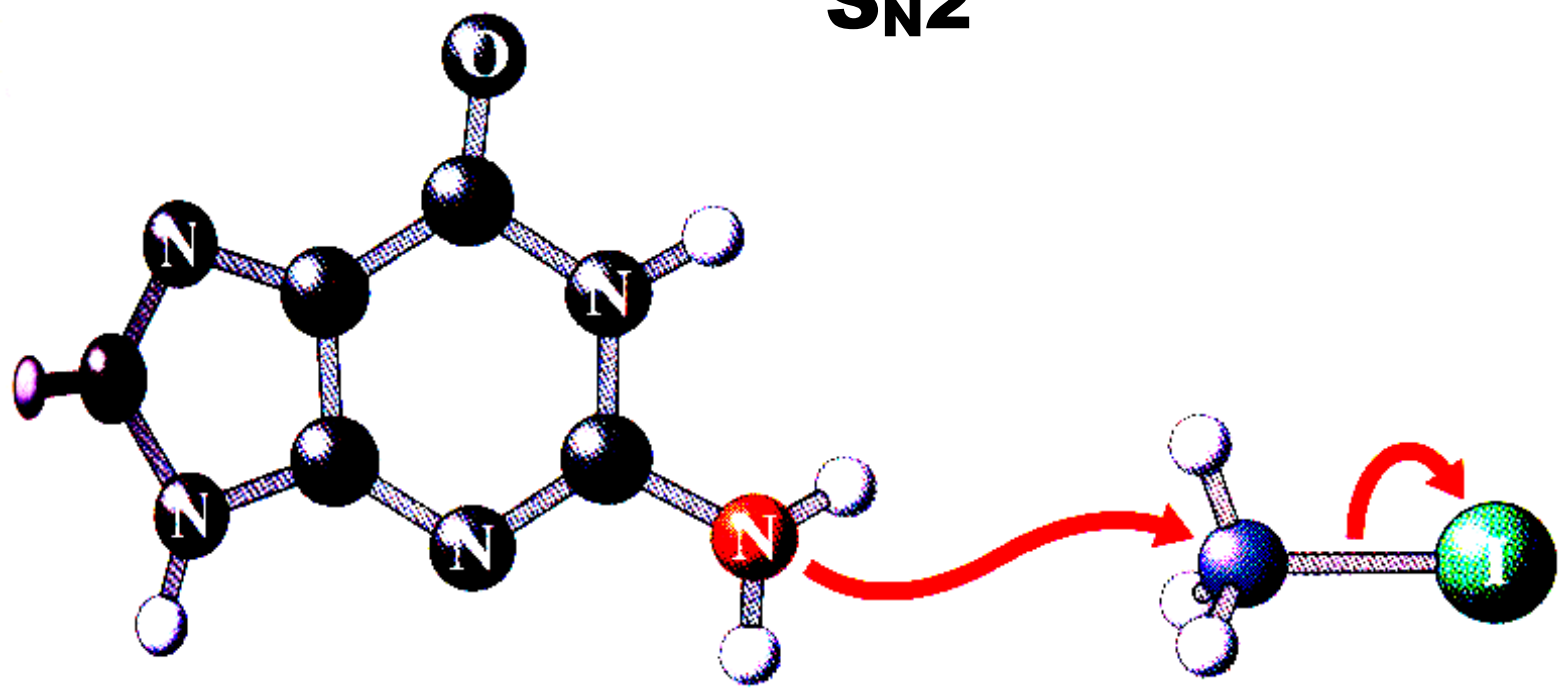


S_N2

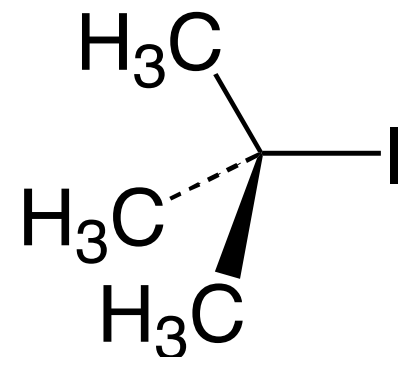
S_N2



S_N2

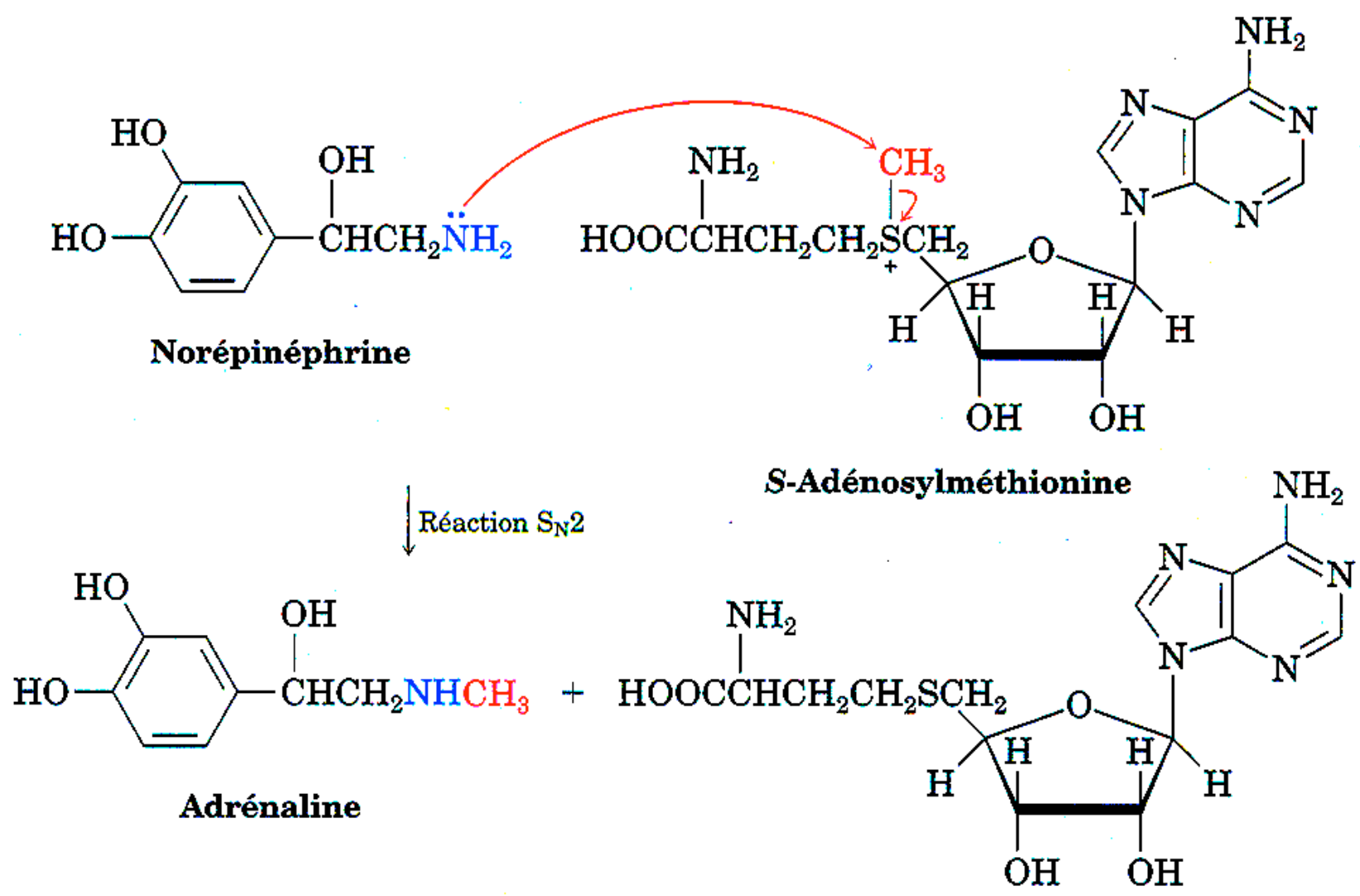


(groupes partants)
(232)



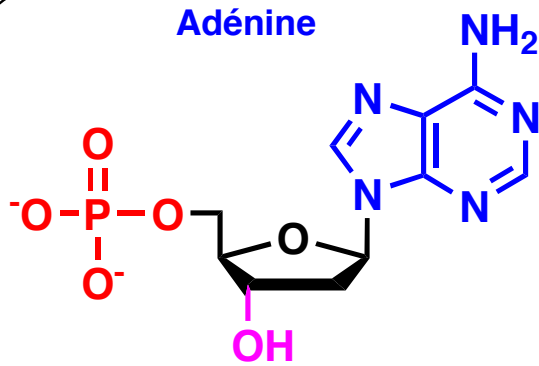
(effet stérique)
(230)

S_N2

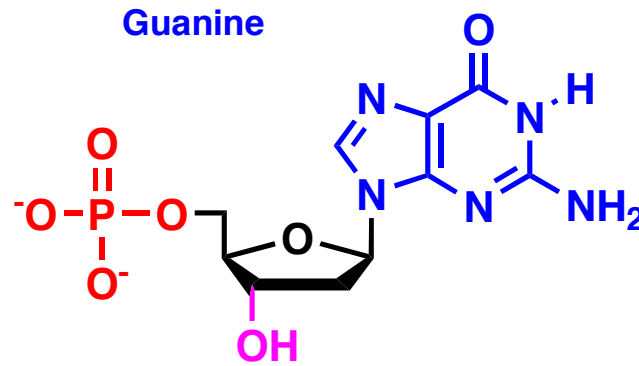


Hétérocycles aromatiques, nucléotides et le code génétique

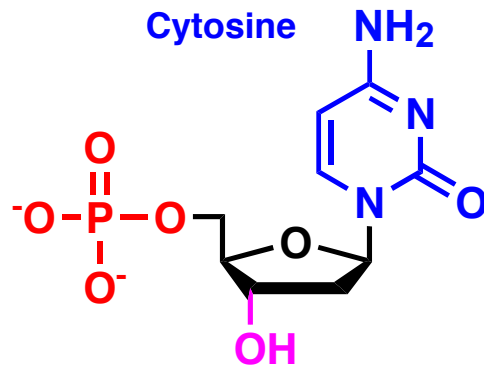
Déoxyribonucléotides



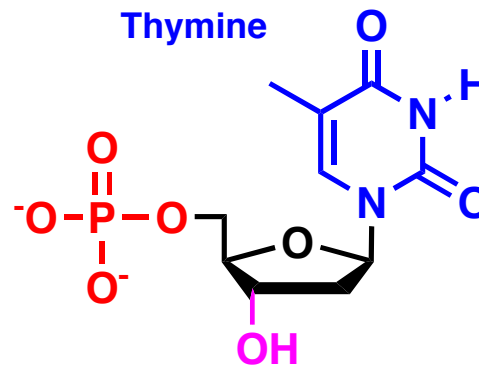
2'-Déoxyadénosine
5'-phosphate



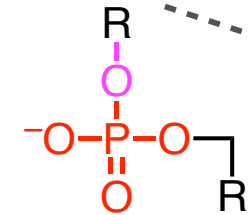
2'-Déoxyguanosine
5'-phosphate



2'-Déoxycytidine
5'-phosphate



2'-Déoxythymidine
5'-phosphate



Aromaticité

A

Alternance de liaisons simples et multiples avec recouvrement des orbitales p

B

Délocalisation d'électrons dans des molécules représenté par une combinaison virtuelle de structures aux électrons localisés différemment

C

**Un cycle d'atomes avec une orbitale p et $4n + 2$ électrons délocalisés
(= système π conjugué formé de liaisons doubles et de doublets non-liants)**

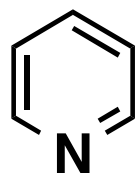
D

Représentations d'une molécule ne différant que par la position des électrons de liaison

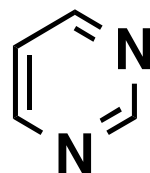
E

Stéréoisomères qui diffèrent par leur stéréochimie au niveau d'une double liaison ou d'un cycle

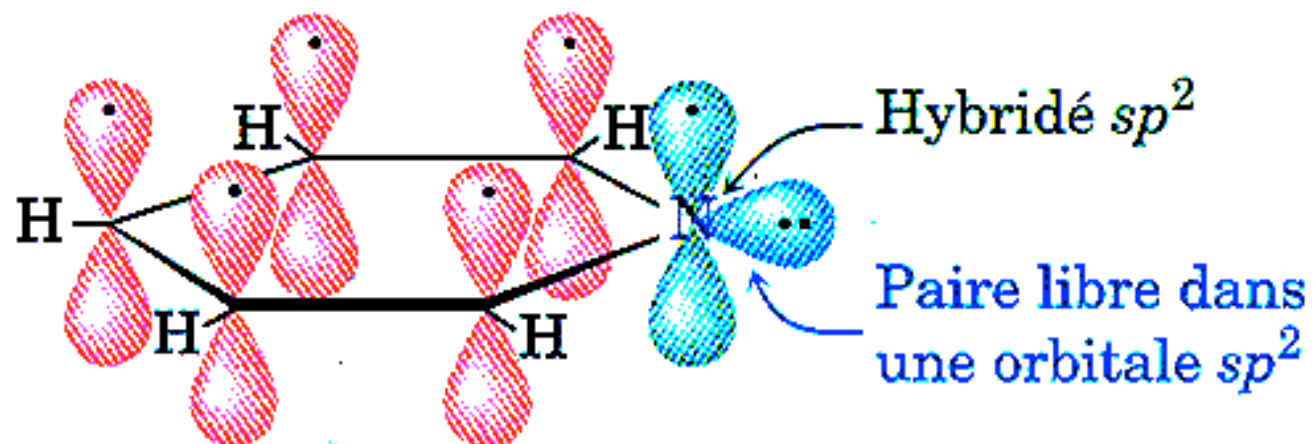
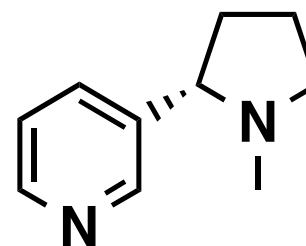
« L'azote sp^2 » hétérocyclique



Pyridine

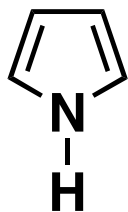


Pyrimidine

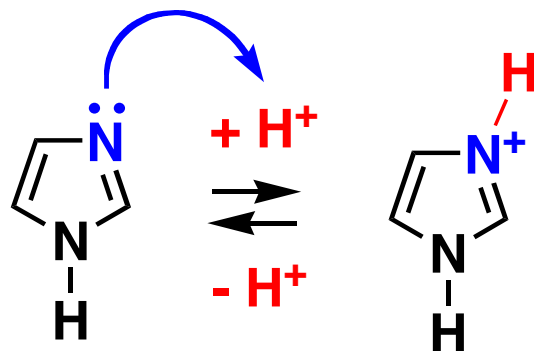


Six électrons π

« L'azote sp^2 » hétérocyclique

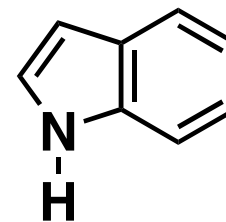


Pyrrole

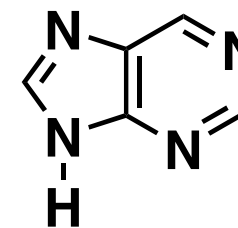


Imidazole

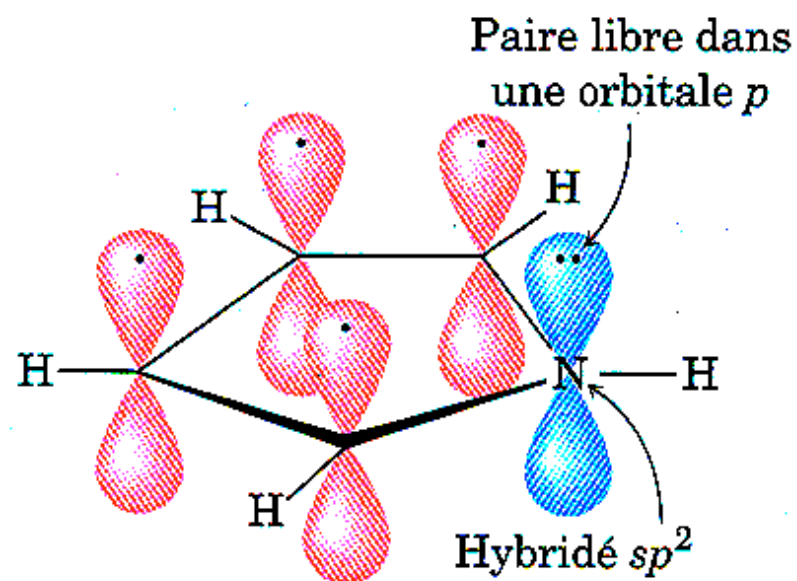
$pK_a \sim 6$



Indole

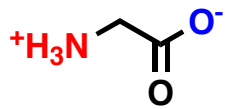


Purine



Six électrons π

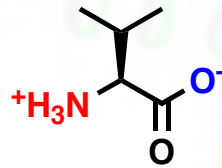
Les acides aminés (pH = 7)



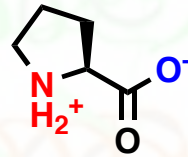
Glycine
(Gly, G)



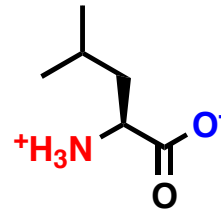
Alanine
(Ala, A)



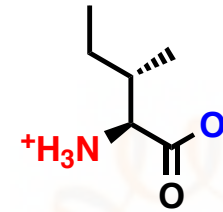
Valine
(Val, V)



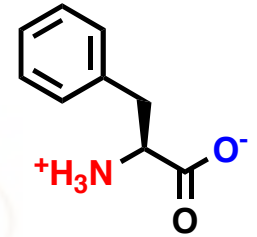
Proline
(Pro, P)



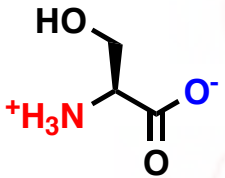
Leucine
(Leu, L)



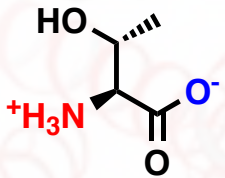
Isoleucine
(Ile, I)



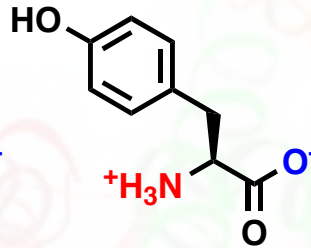
Phénylalanine
(Phe, F)



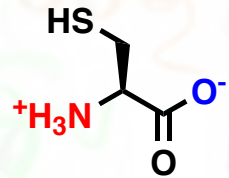
Sérine
(Ser, S)



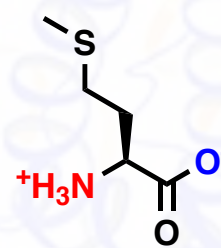
Thréonine
(Thr, T)



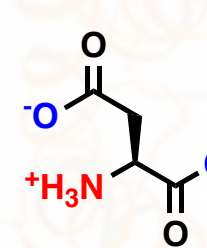
Tyrosine
(Tyr, Y)



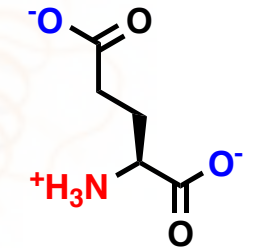
Cystéine
(Cys, C)



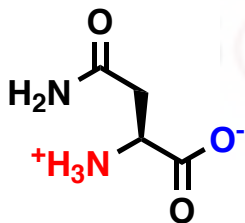
Méthionine
(Met, M)



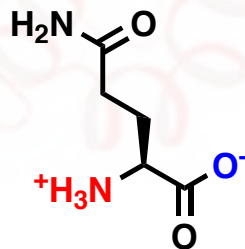
Acide aspartique
(Asp, D)



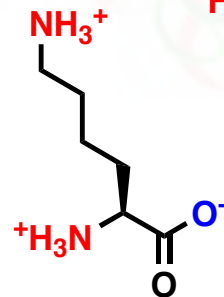
Acide glutamique
(Glu, E)



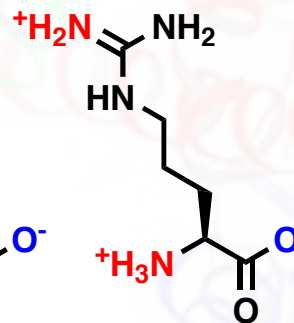
Asparagine
(Asn, N)



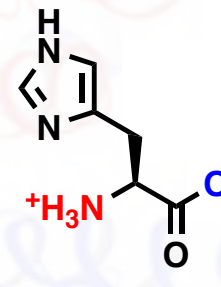
Glutamine
(Gln, Q)



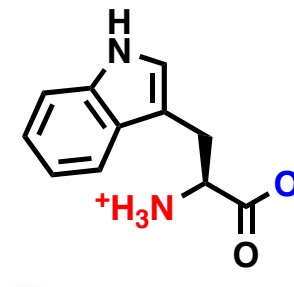
Lysine
(Lys, K)



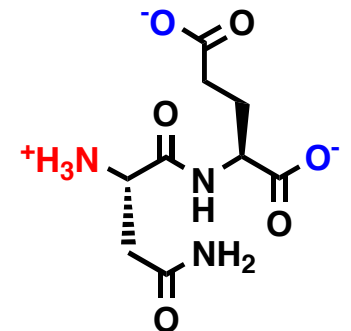
Arginine
(Arg, R)



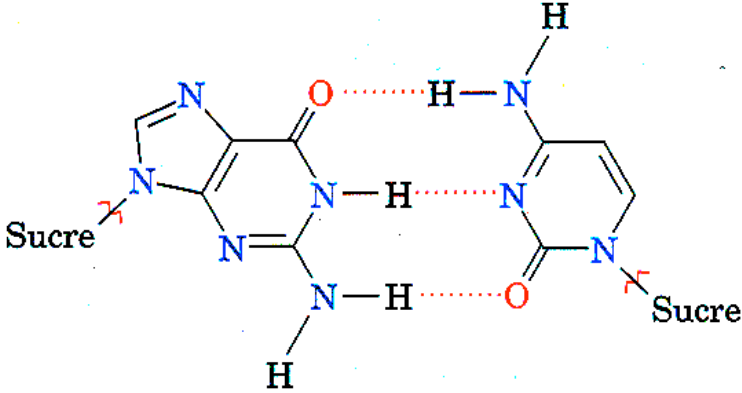
Histidine
(His, H)



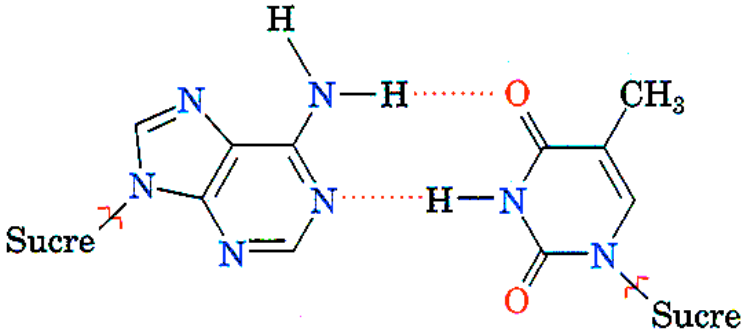
Tryptophane
(Trp, W)



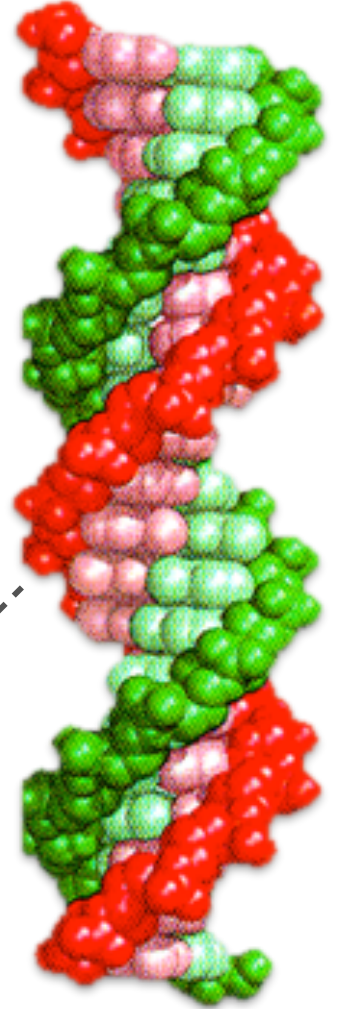
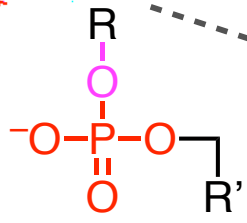
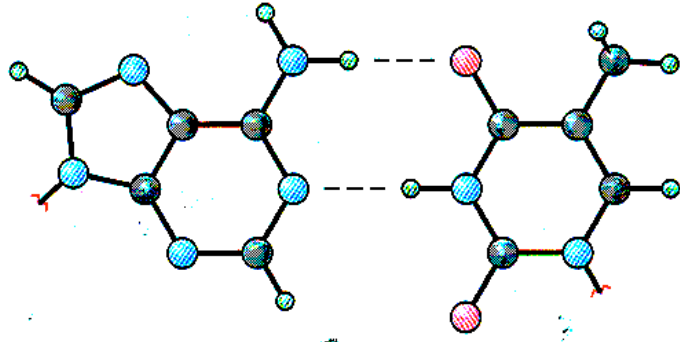
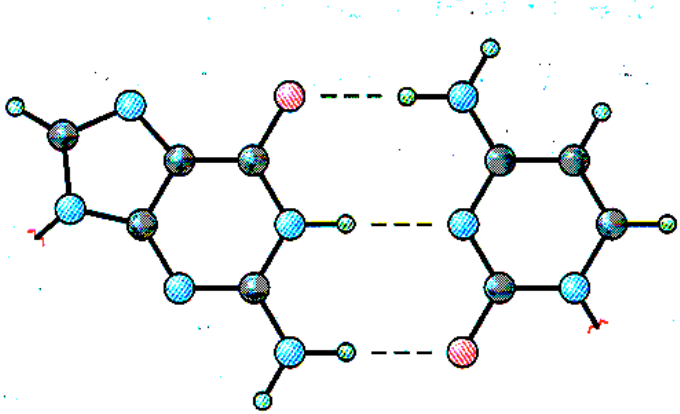
Hétérocycles aromatiques et le code génétique



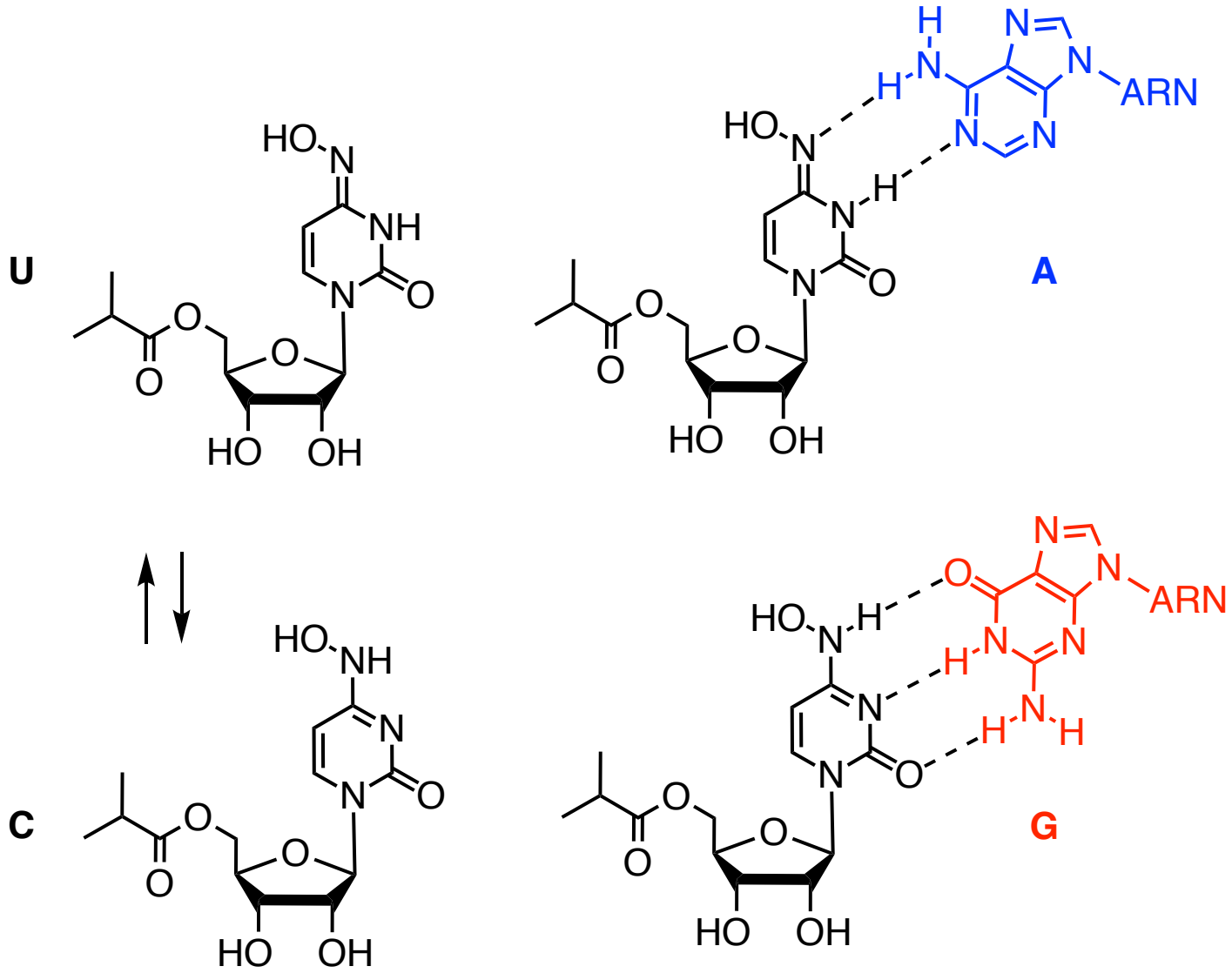
(Guanine) G ::::: C (Cytosine)



(Adénine) A ::::: T (Thymine)



Molnupiravir



Résumé 7 (Acides nucléiques - amines)

- **amine, ammonium (N sp^3)**
- **hétérocycles aromatiques (N sp^2) : pyridine, pyrrole, imidazole, indole (protéines), pyrimidine, purine (ADN)**
- **liaison hydrogène (code génétique)**
- **acidité, résonance, aromaticité :**
 - **alkylamines (protéines) - arylamines (ADN, code génétique)**
 - **amide (protéines)**
 - **hétérocycles aromatiques (ADN, protéines)**
- **substitution nucléophile S_N2 : C sp^3 électrophile, sans intermédiaire réactionnel (cigarettes, adrénaline)**