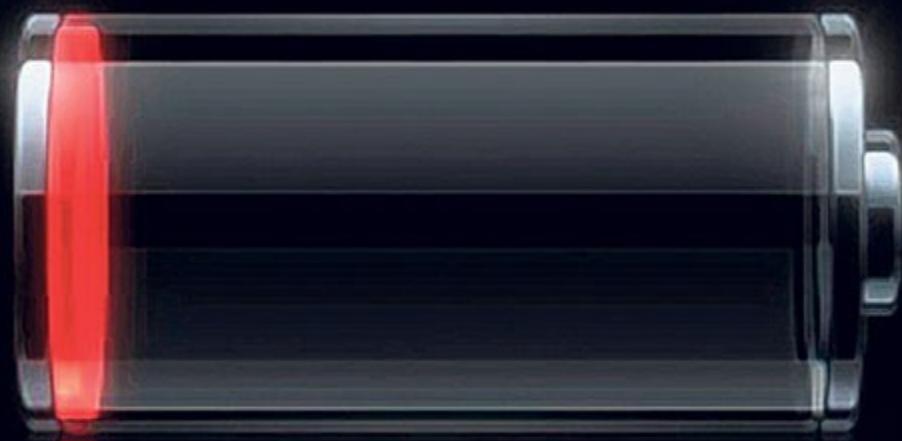


Faculté de Médecine de Sfax  
UEF 109

# Bioénergétique 1/2

Cliniquement,  
comment un déficit énergétique de  
l'organisme se manifeste-t-il ?



Batterie faible

Troubles visuels,

Céphalées

Difficultés intellectuelles,

Faiblesse musculaire,

Hypothermie,

Défaillance des organes vitaux,

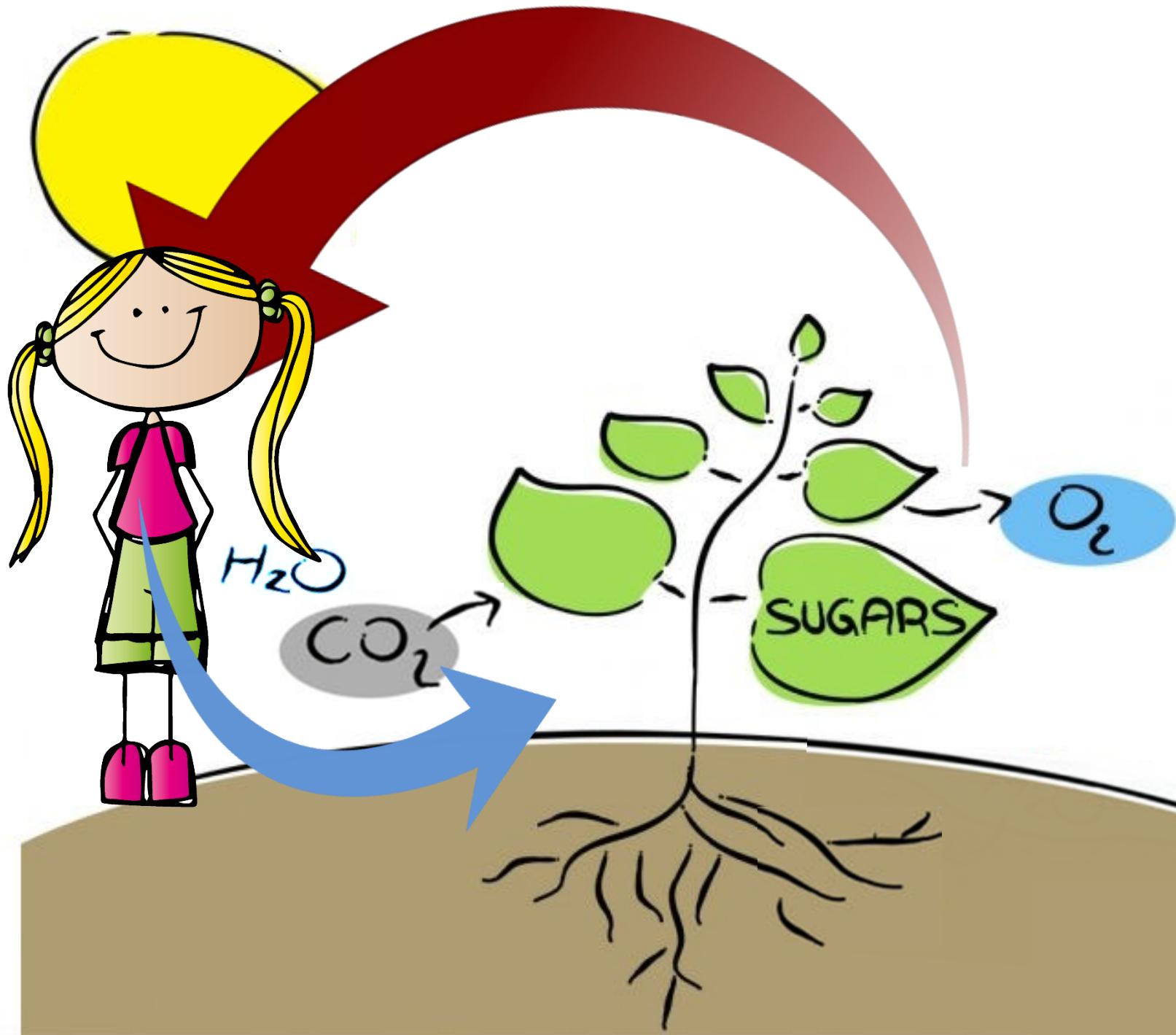
...

Comment rechargeons-nous  
nos batteries cellulaires ?

# Comment rechargeons-nous nos batteries cellulaires ?

Premier principe de la thermodynamique

**Loi de conservation de l'énergie**  
L'énergie d'un système ni se perd ni  
se crée, elle se transforme



Troubles visuels,

Céphalées

Difficultés intellectuelles,

Faiblesse musculaire,

Hypothermie,

Défaillance des organes vitaux,

...



Tout système physique  
laissé à lui-même,  
comme un être vivant,  
tend à se désorganiser

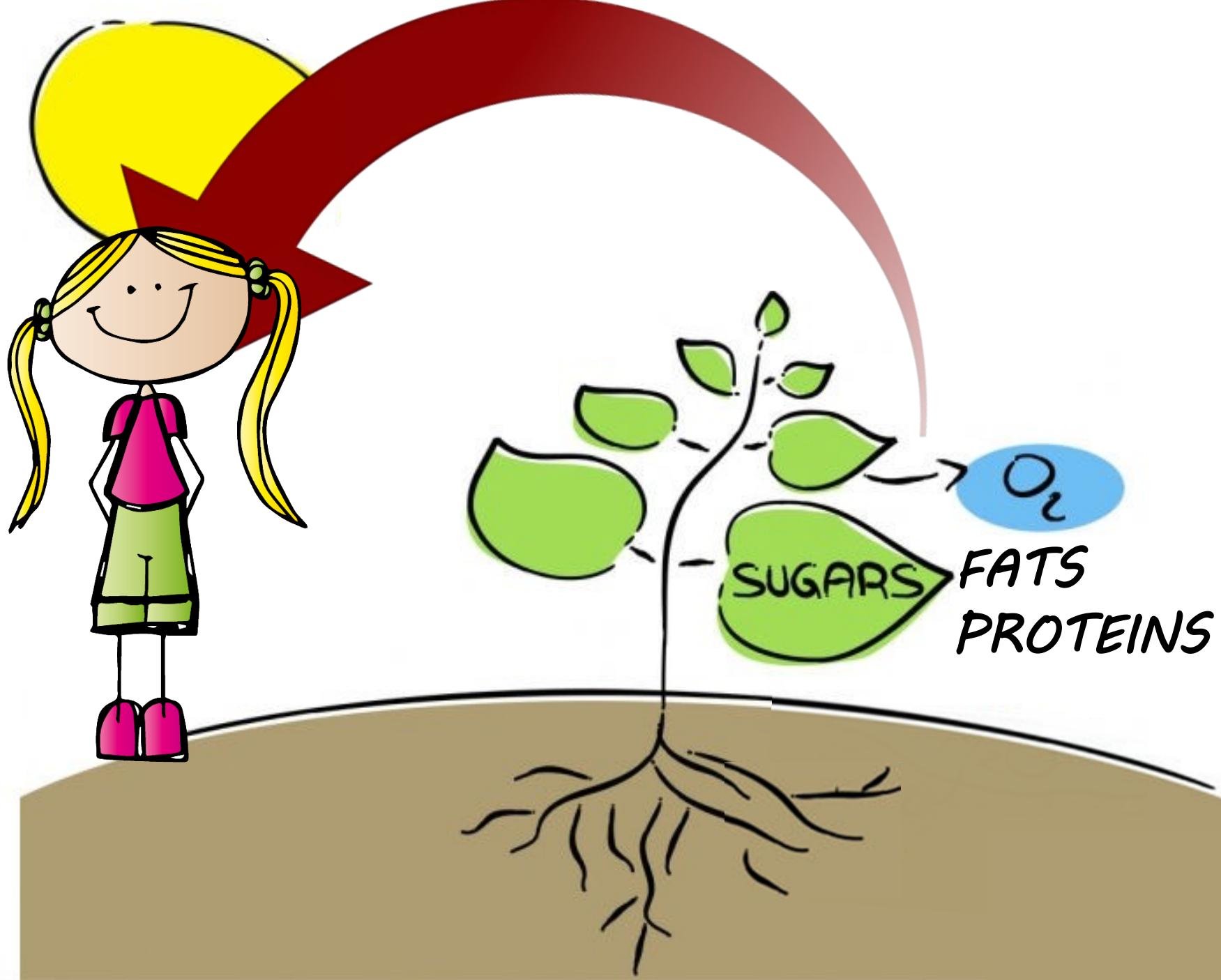
# Deuxième principe de la thermodynamique

Tout système est caractérisé par une fonction d'état  $S$  appelée **ENTROPIE** (désordre).

Cette fonction **entropie** ne peut qu'augmenter pour un système isolé et fermé.

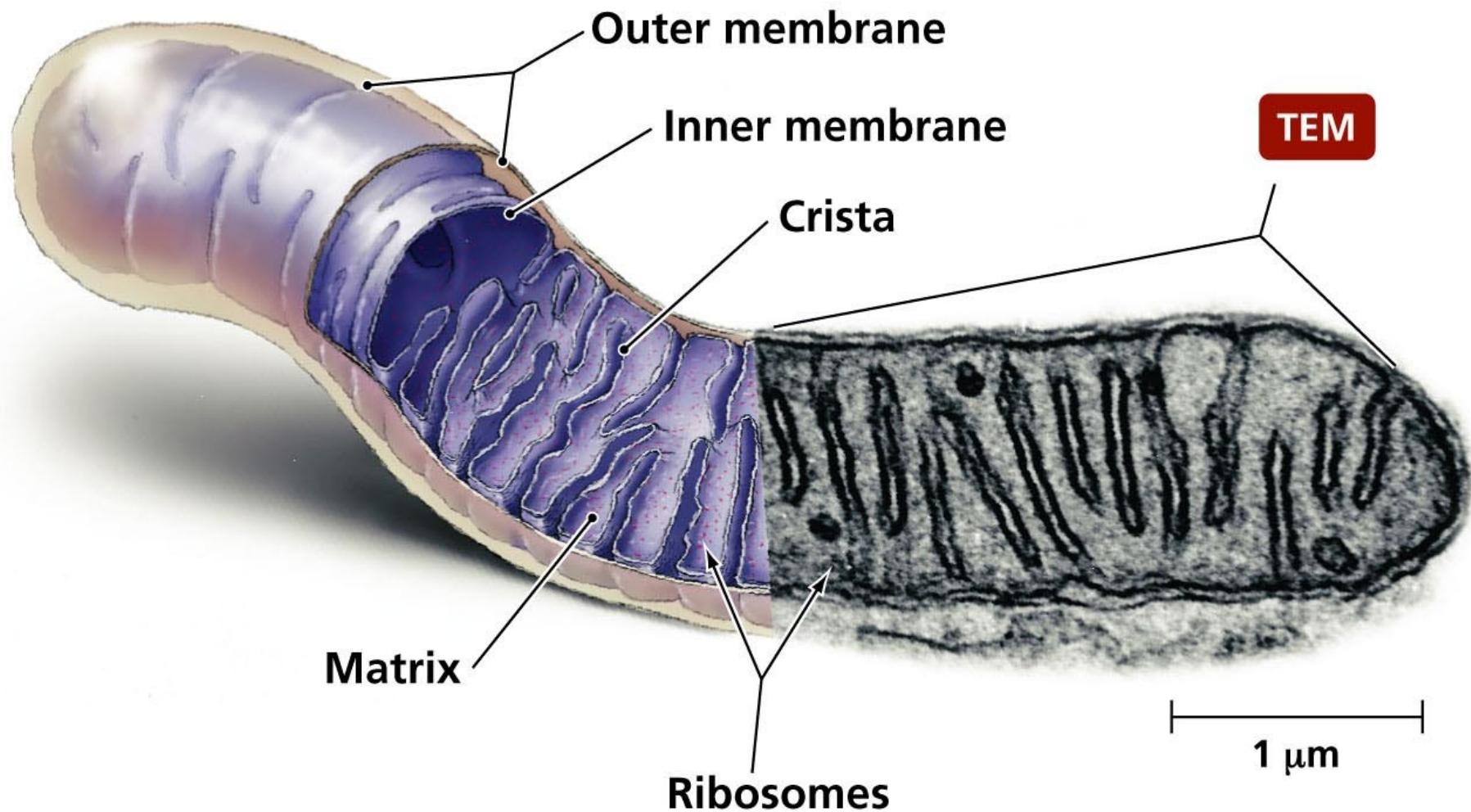
# Anabolisme cellulaire

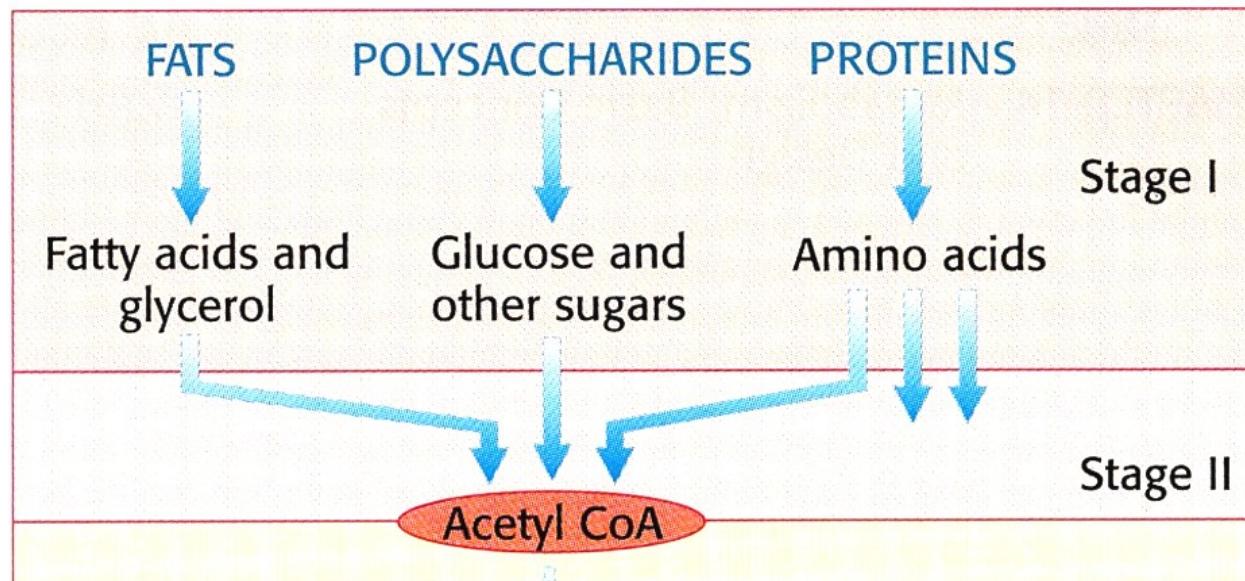


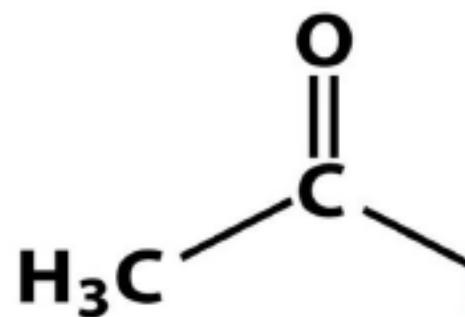




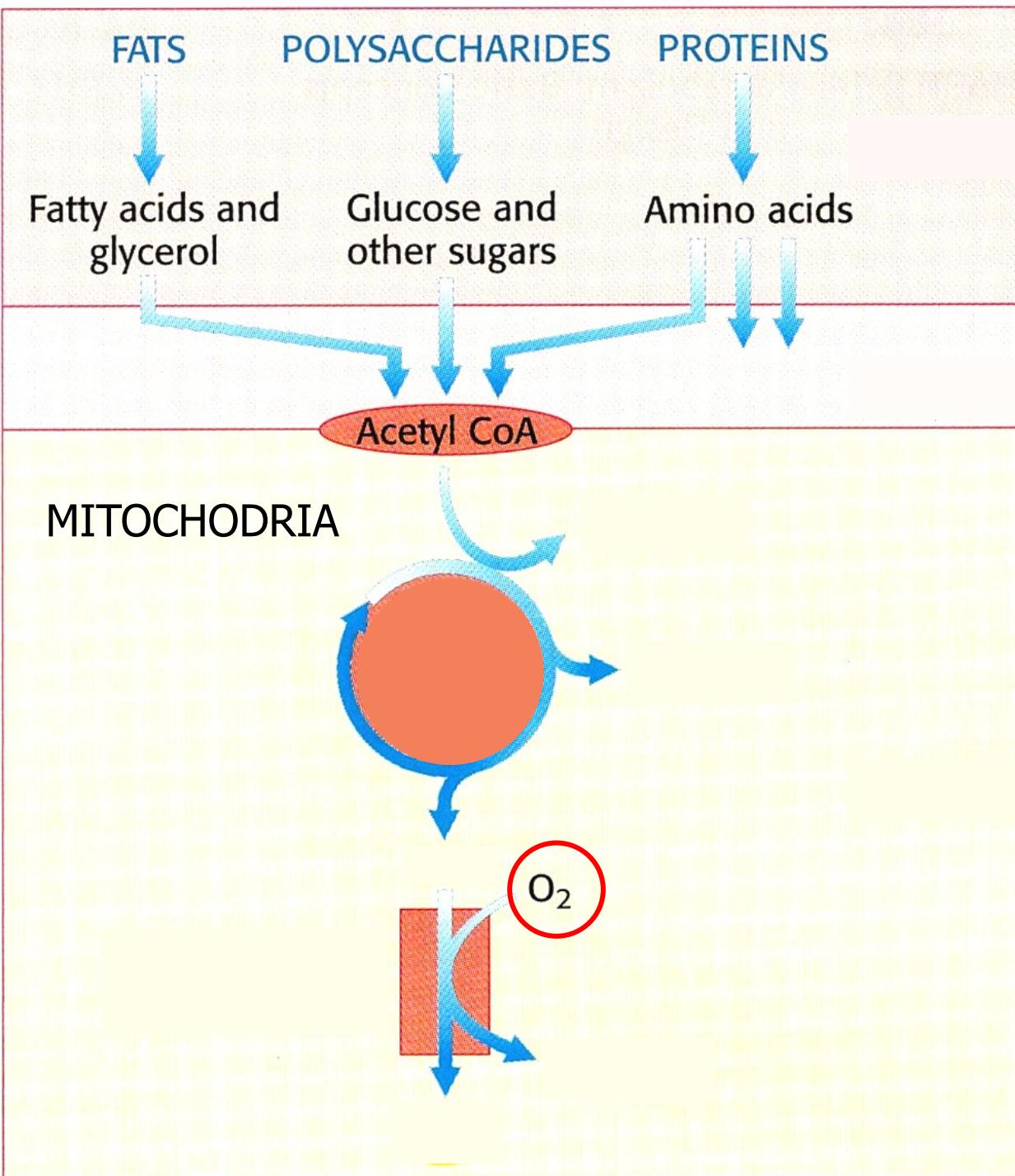
# La Mitochondrie : centrale énergétique

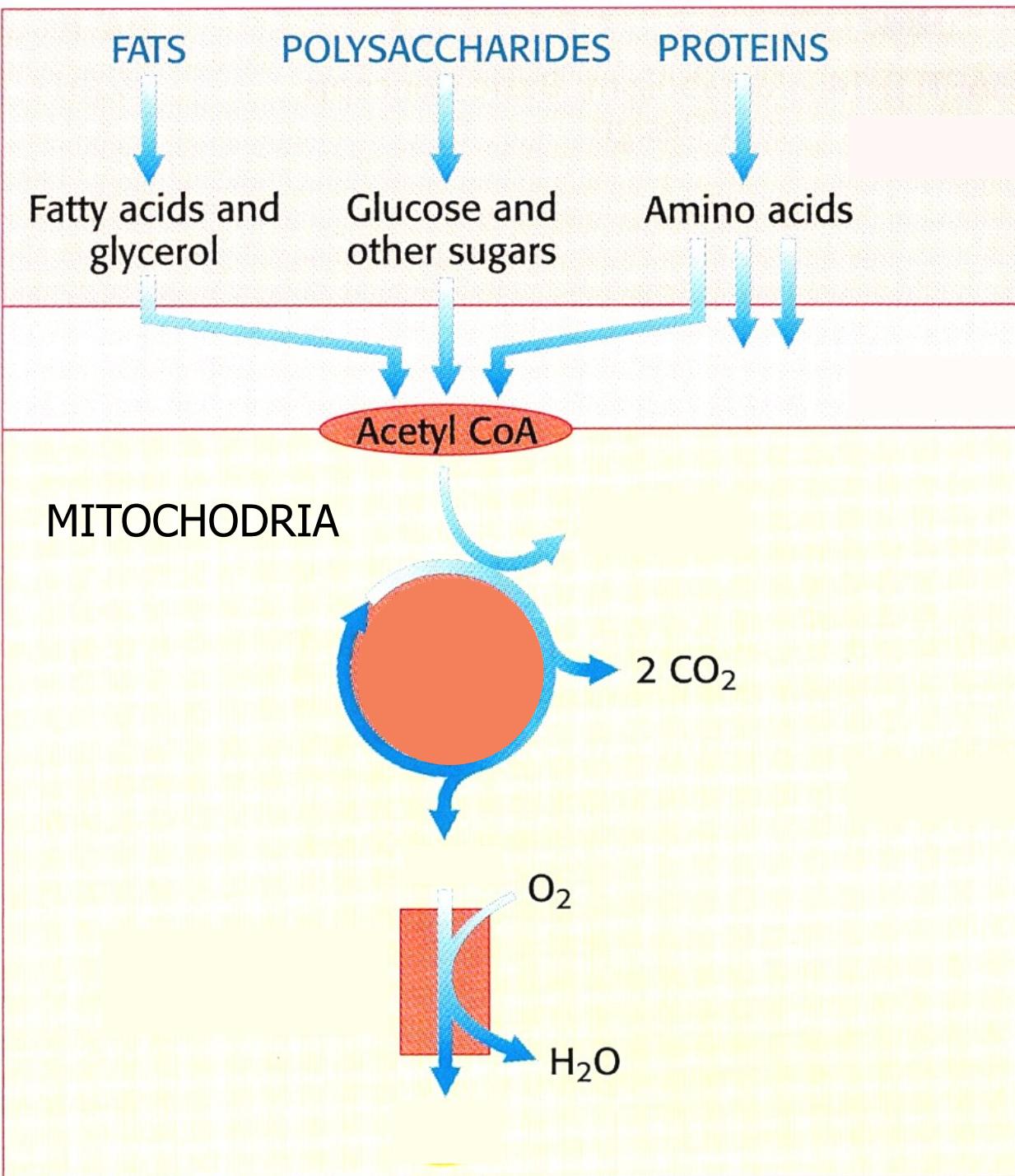


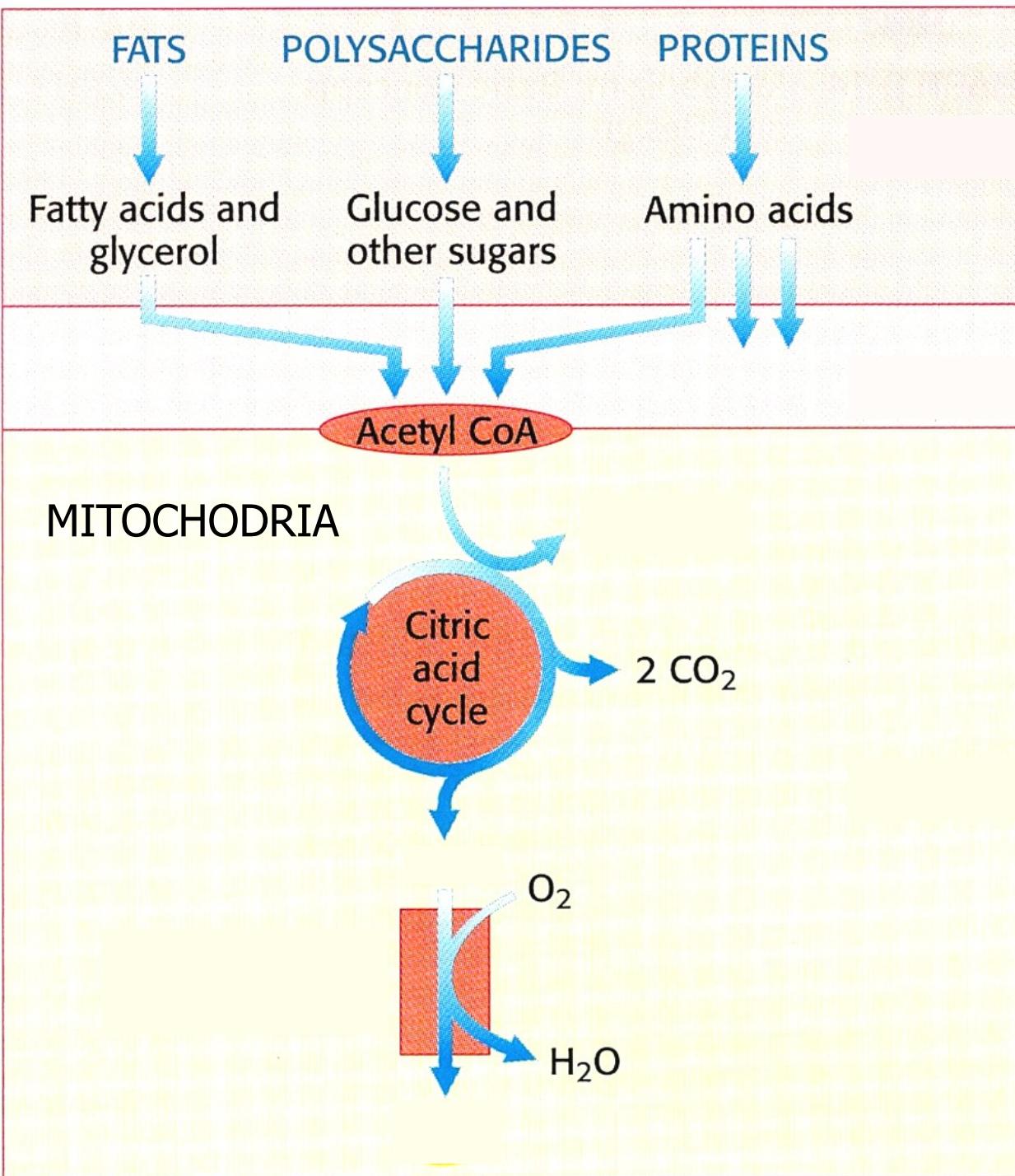


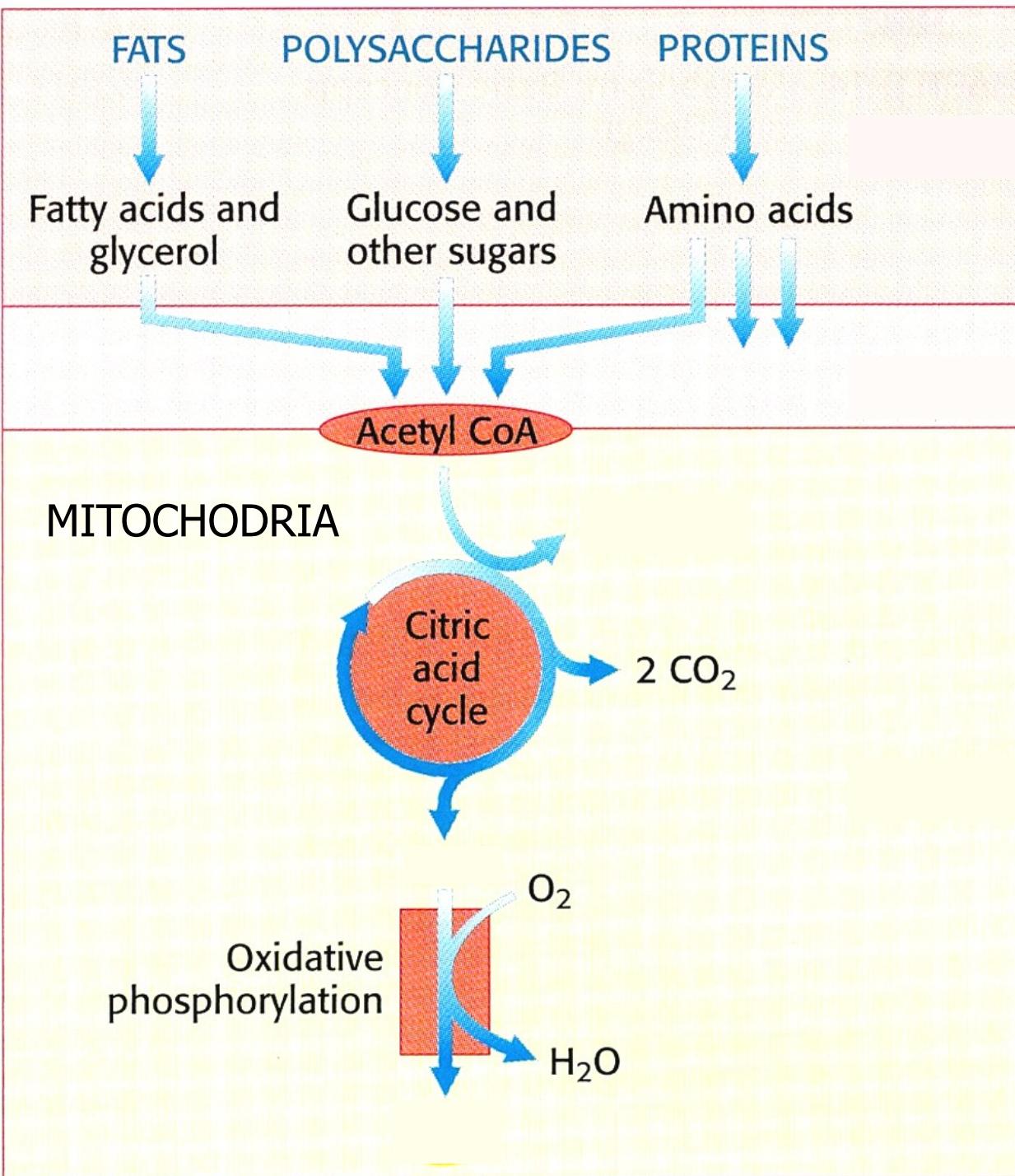


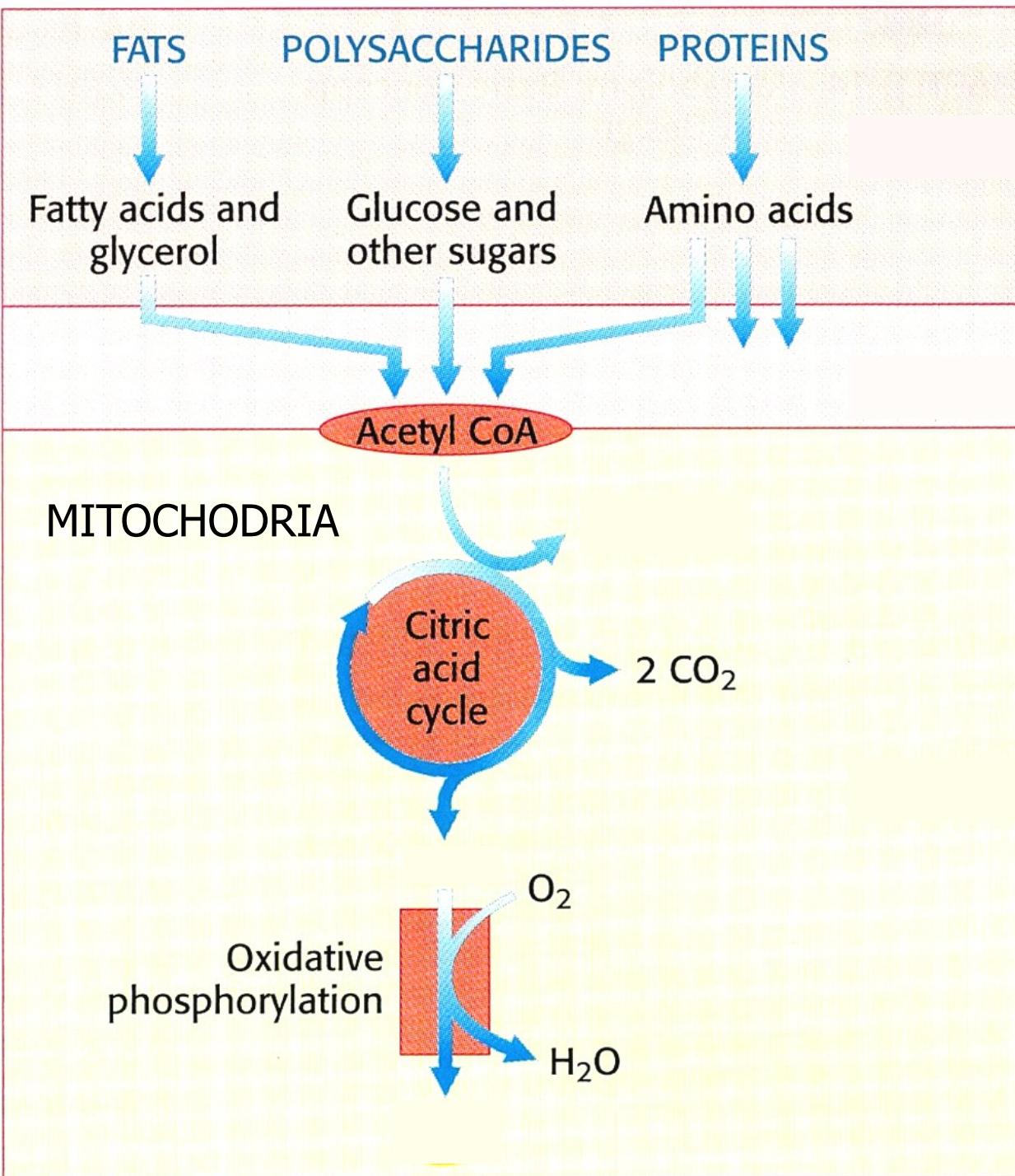
**Acetyl**

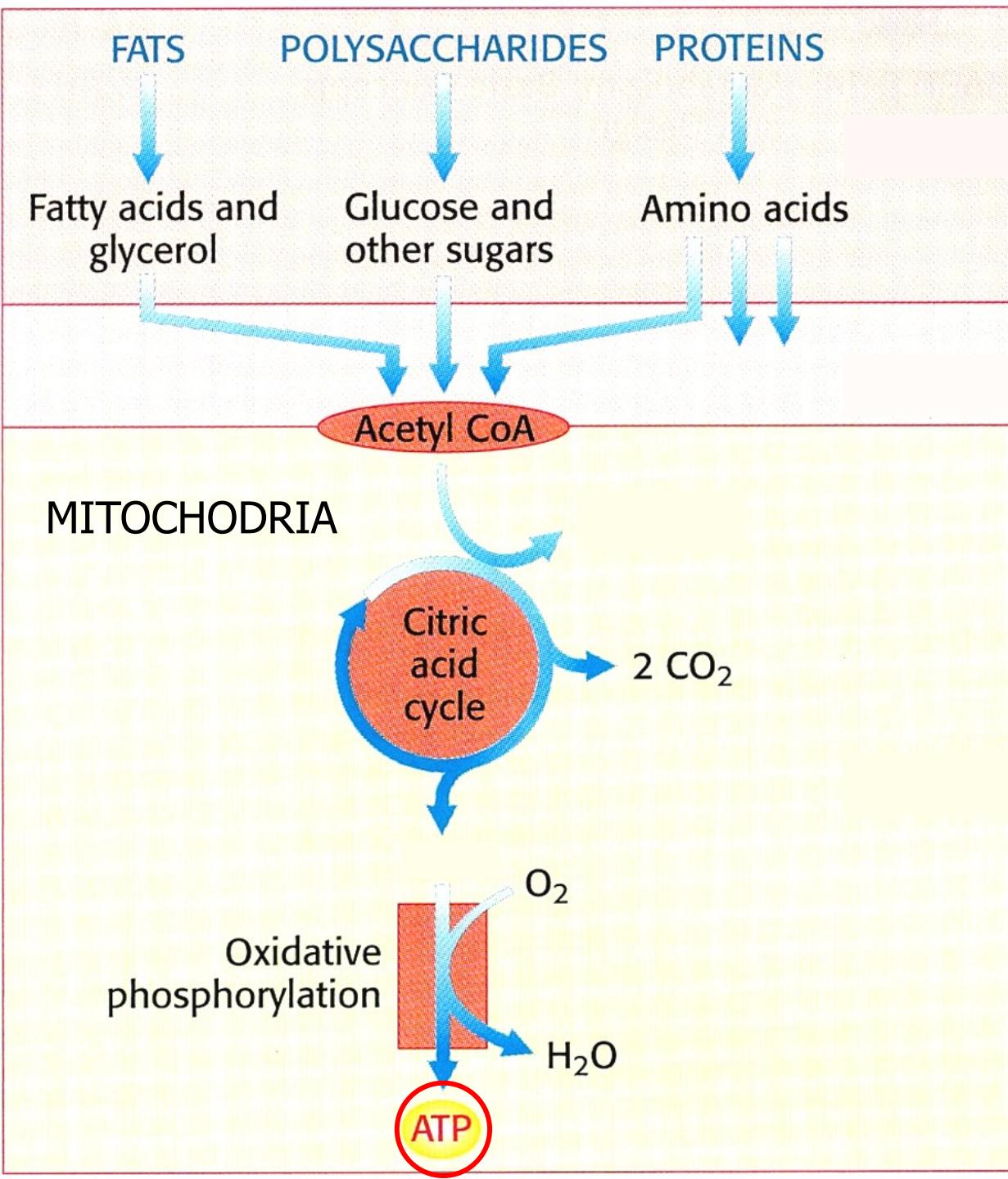


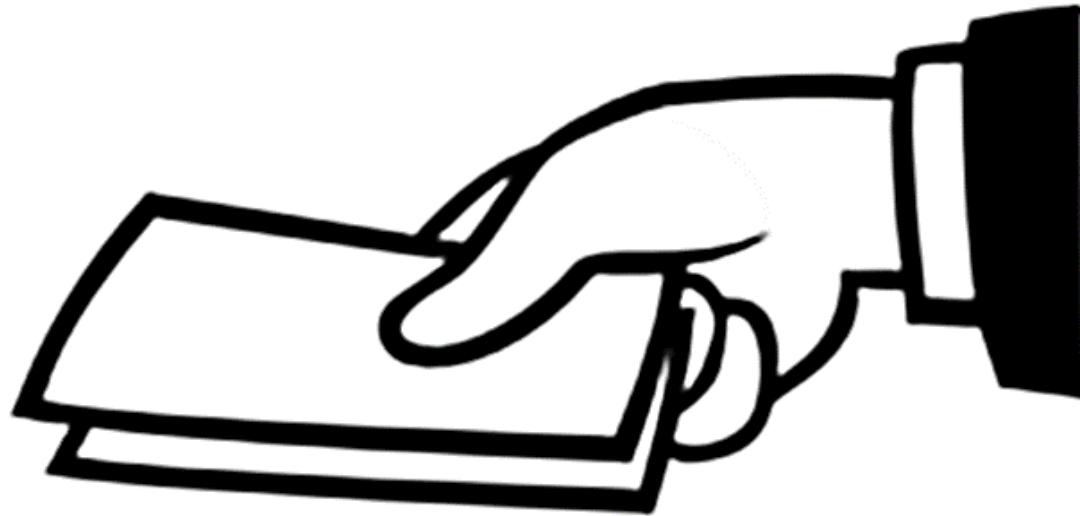




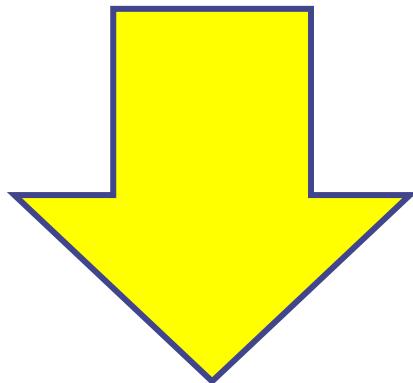
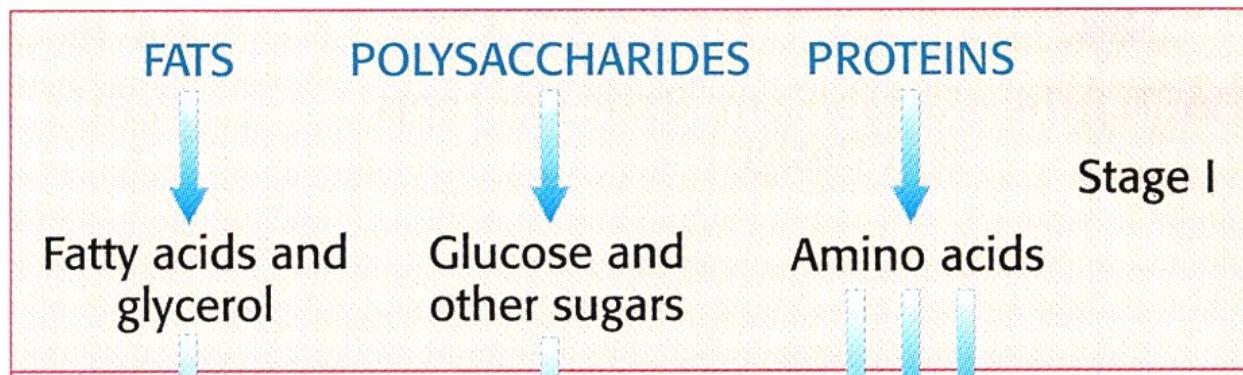








**Main currency**



# ATP

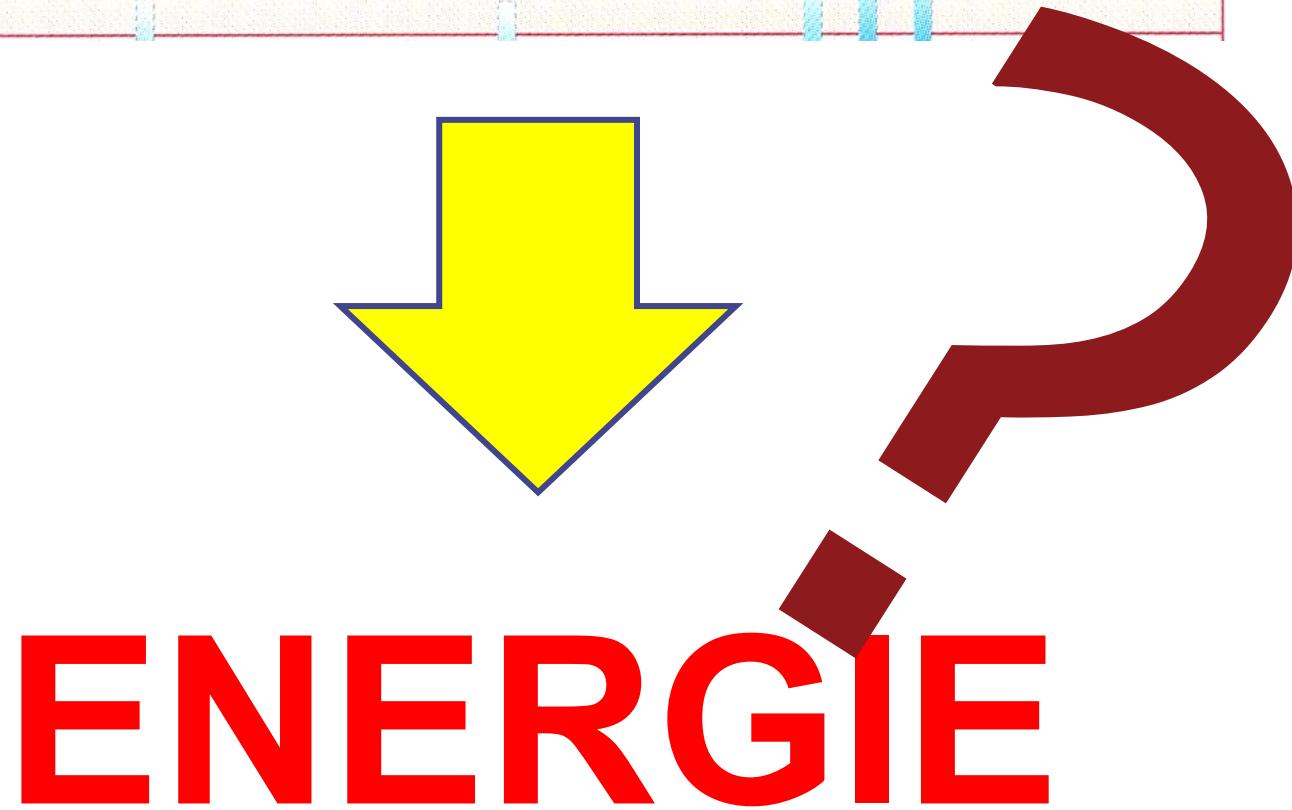
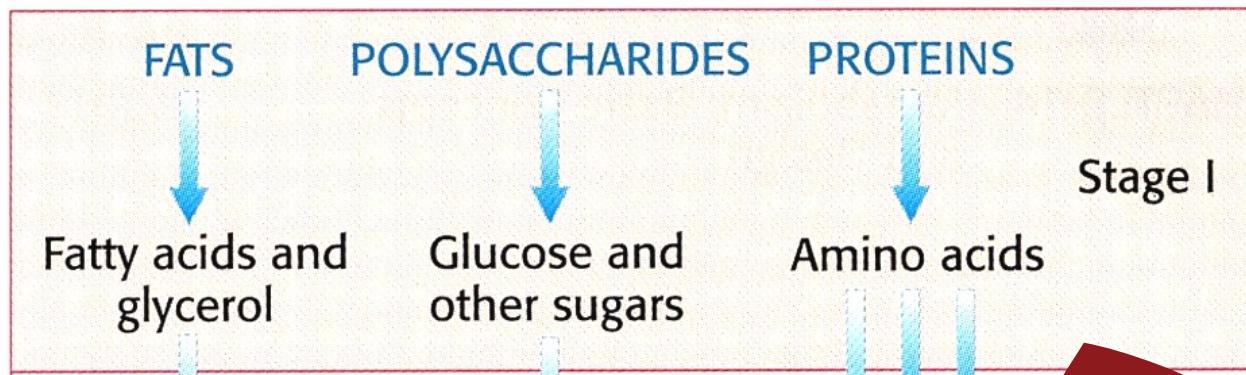
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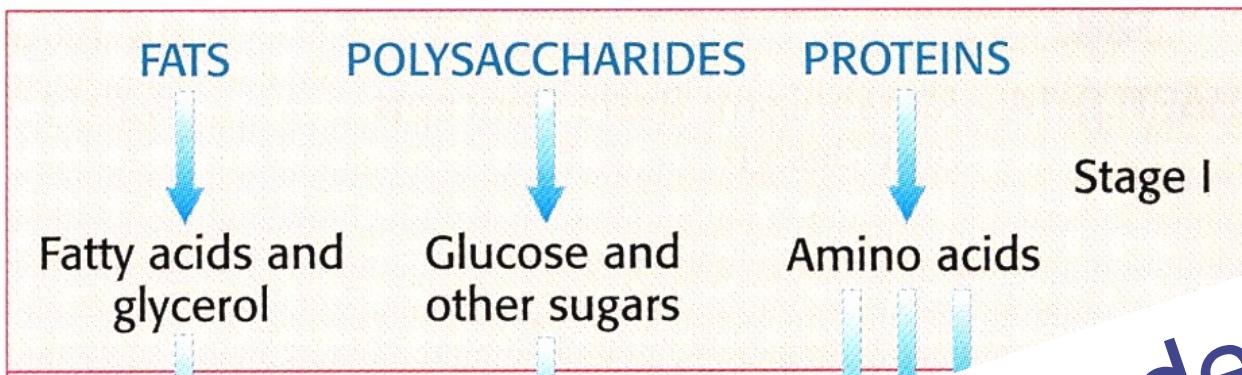
Kgl jour

$\text{CO}_2$

RESPIRATION  
CELLULAIRE



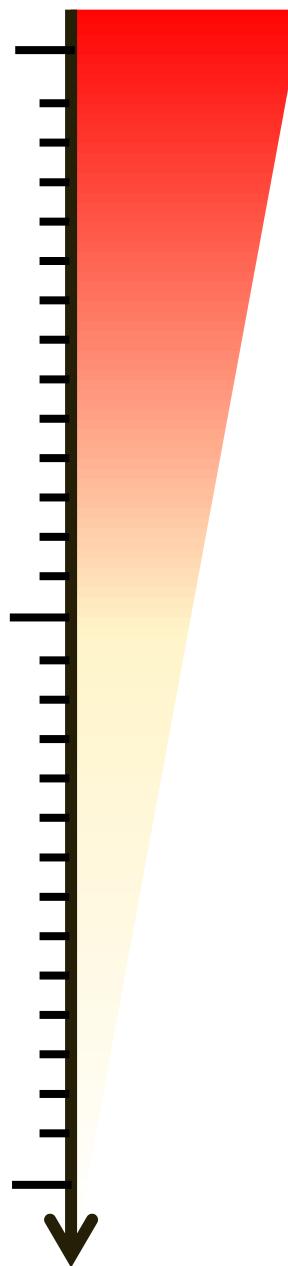


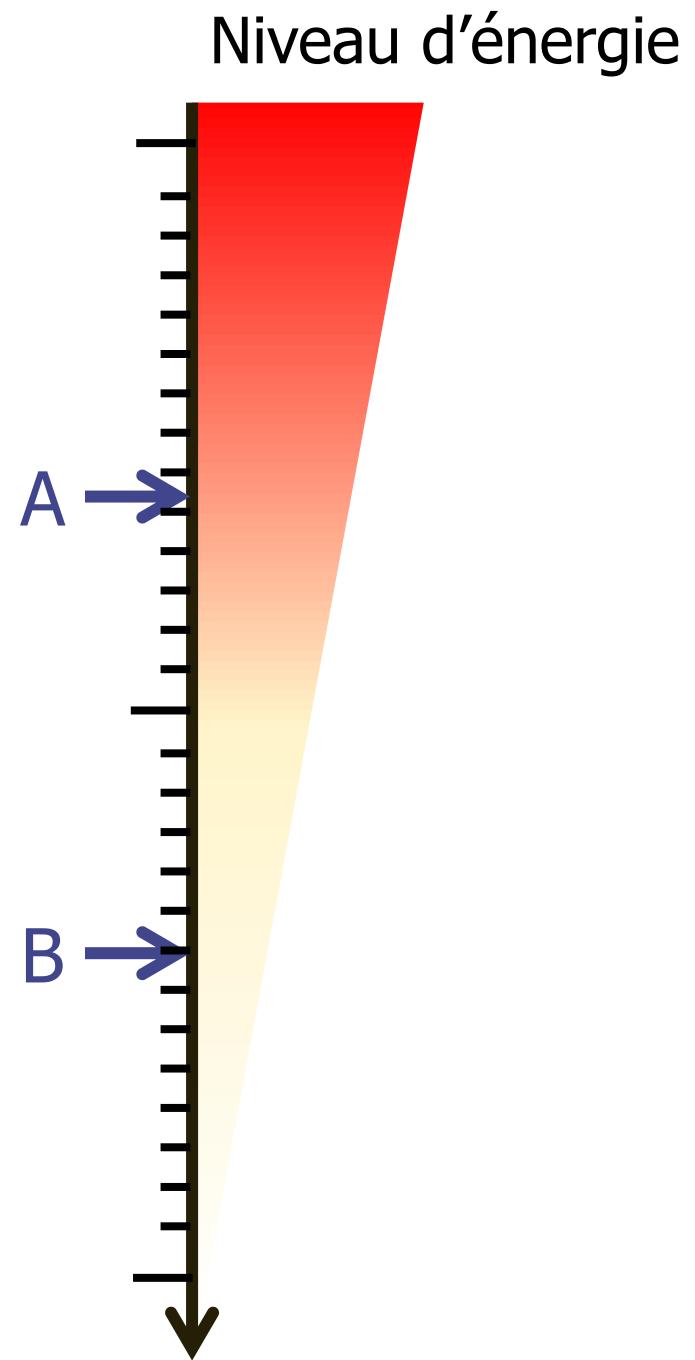
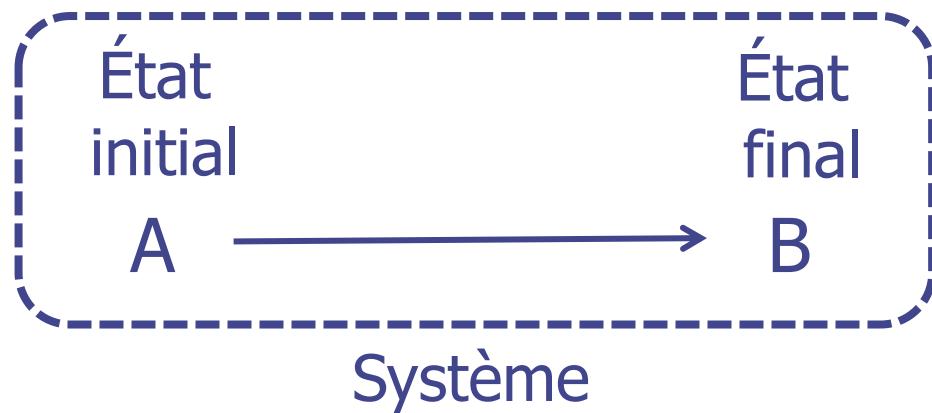


Peuvent s'engager dans des  
transformations EXERGONIQUES

# ENERGIE

Niveau d'énergie





État initial

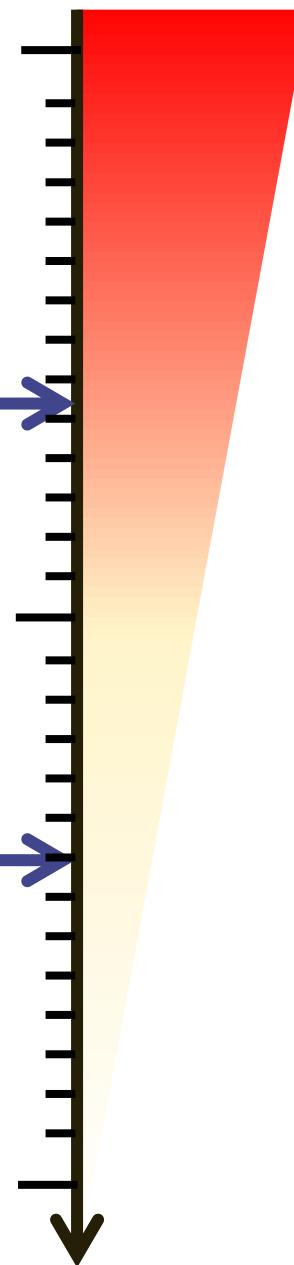
A

État final

B

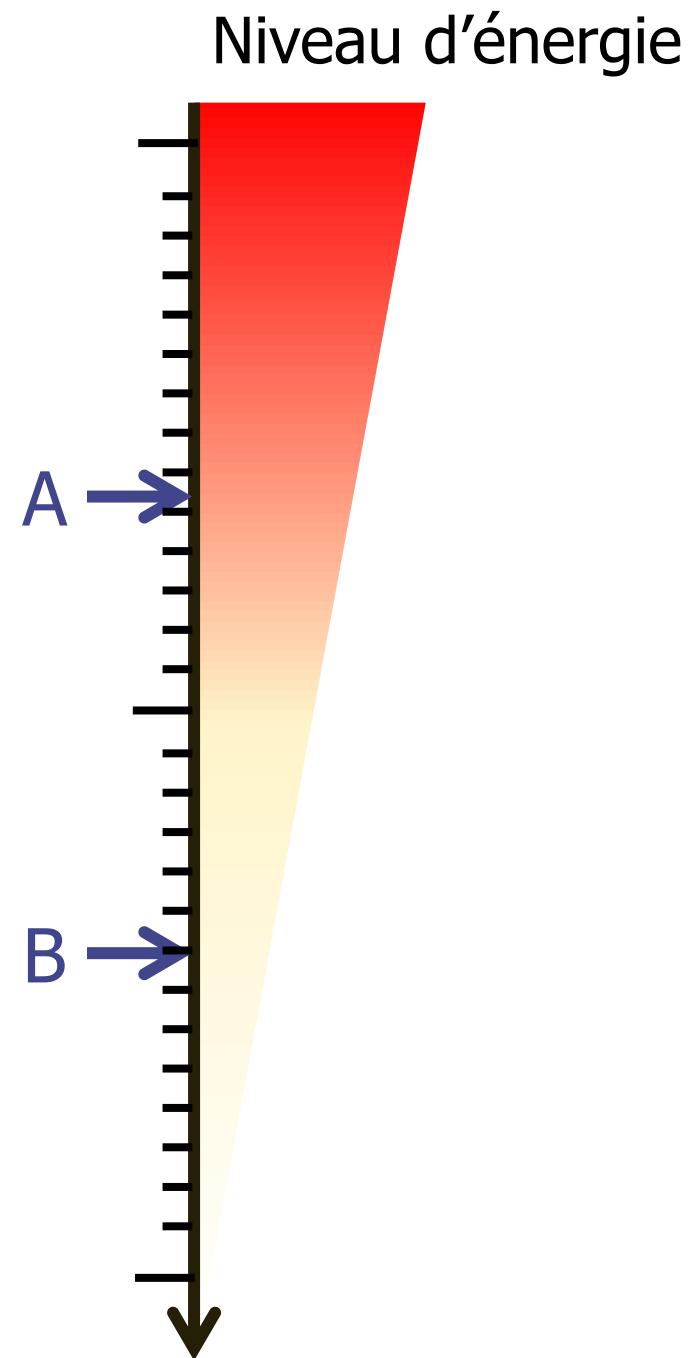
Energie libre  $\Delta G$

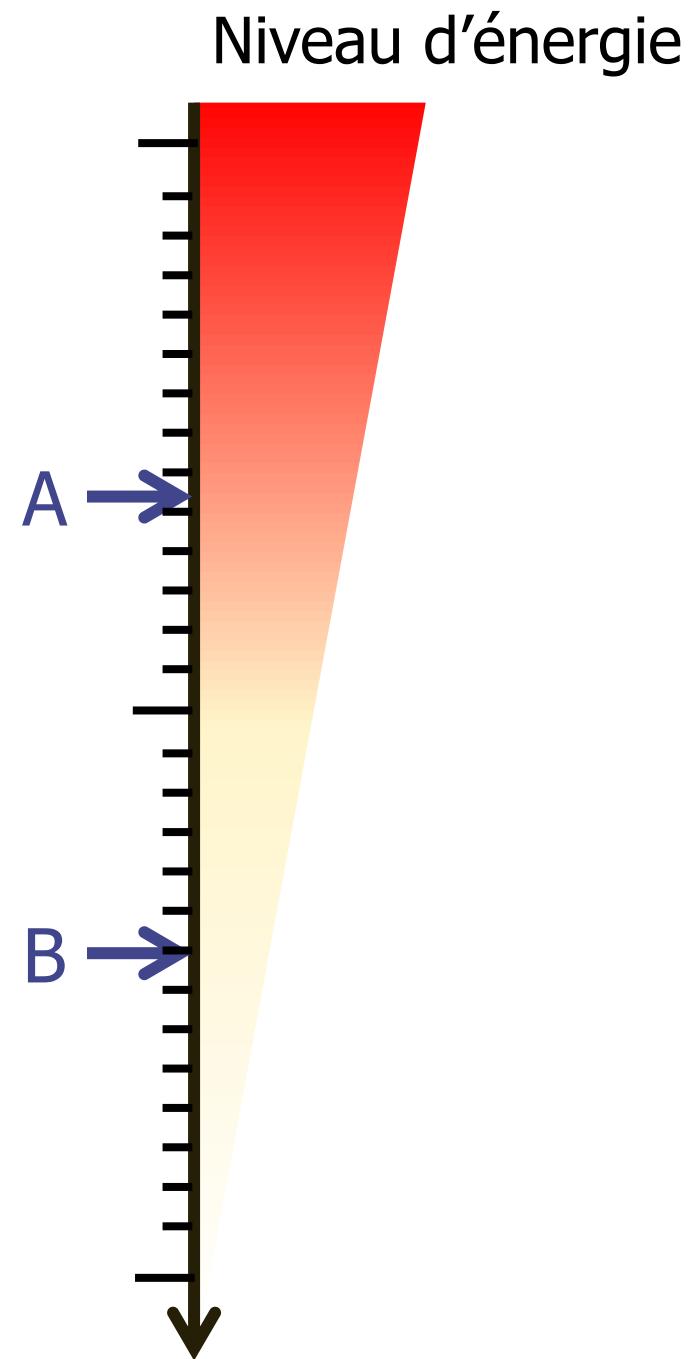
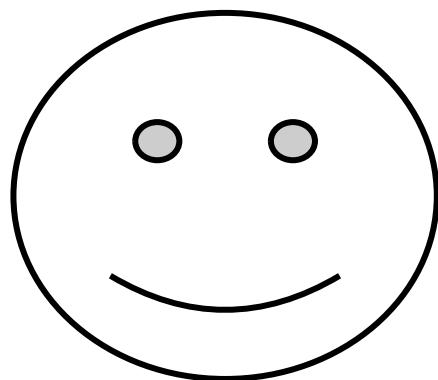
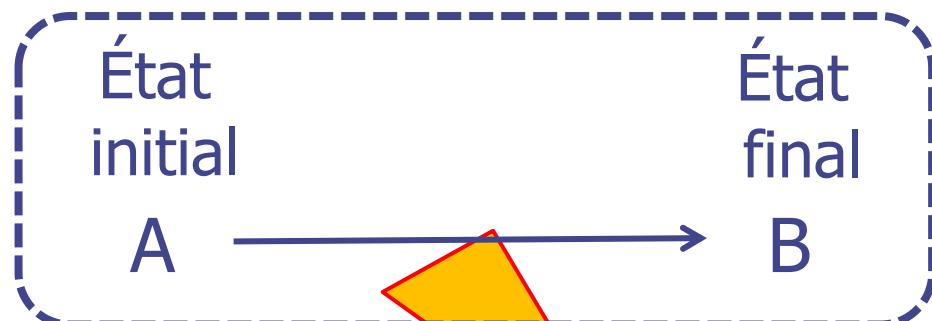
Niveau d'énergie

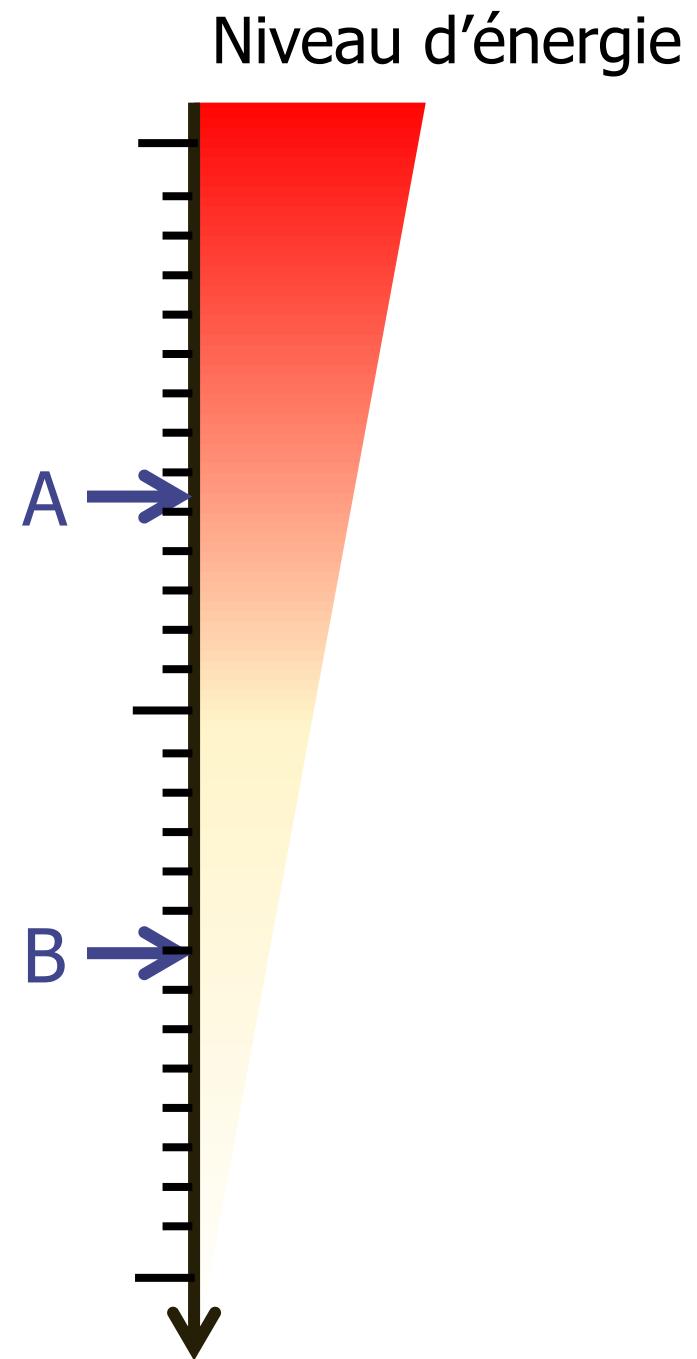
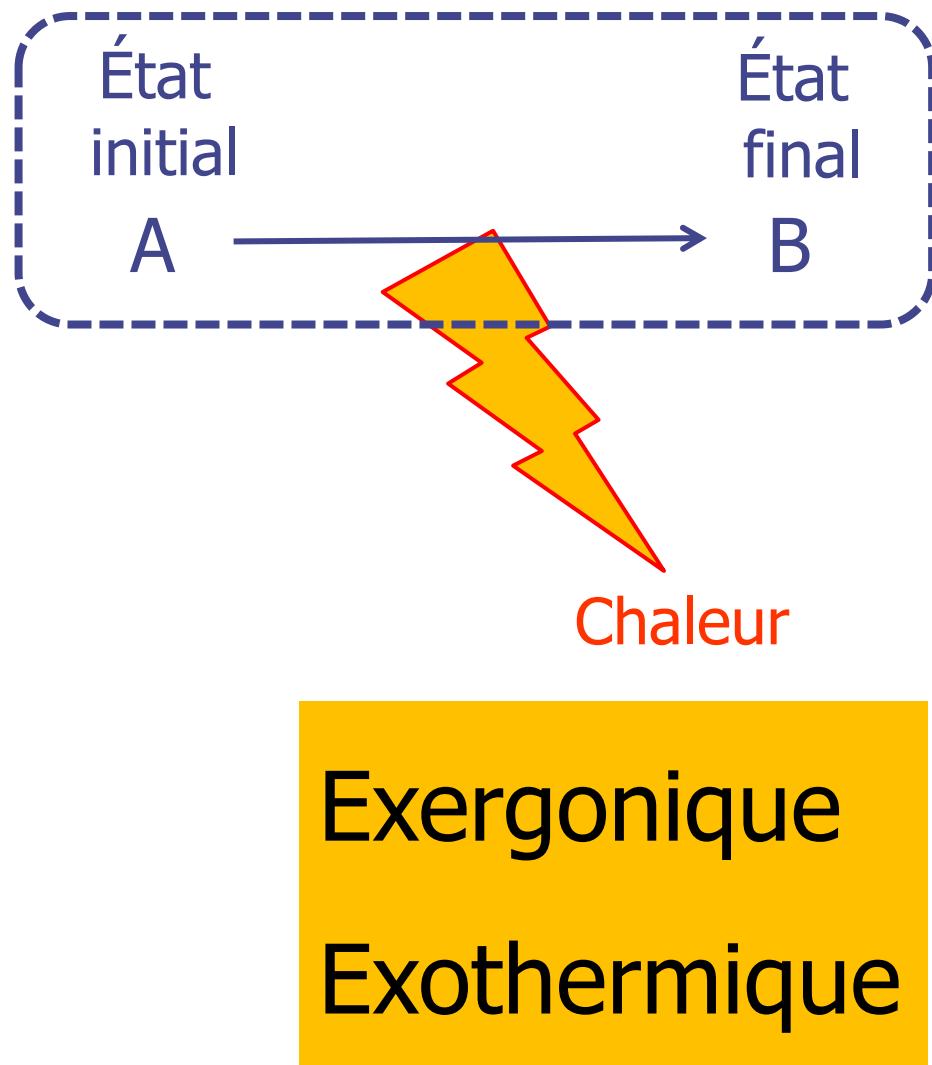




Spontanée ?







État initial

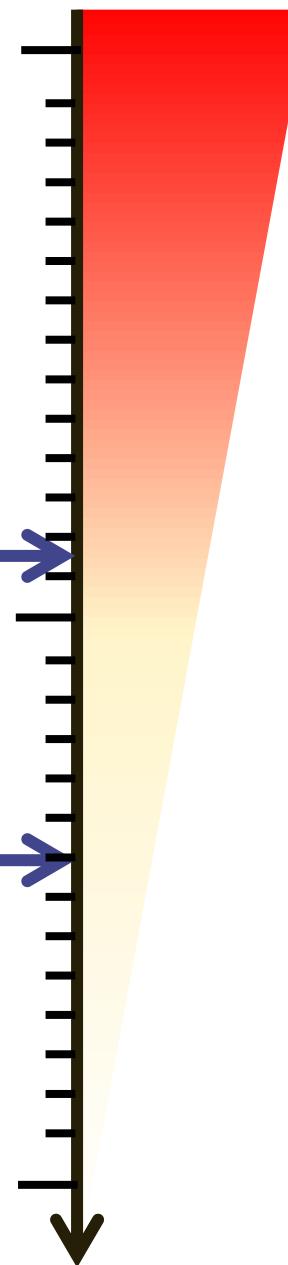
C

État final

D

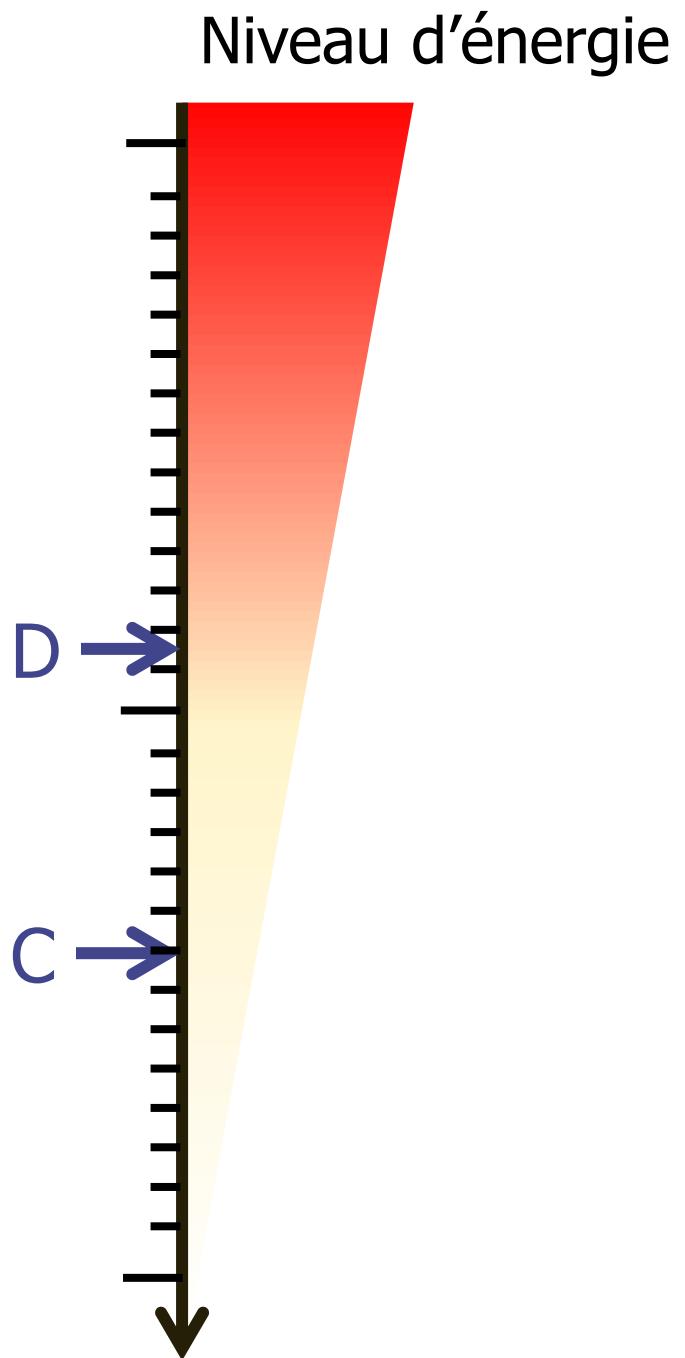
Energie libre  $\Delta G$

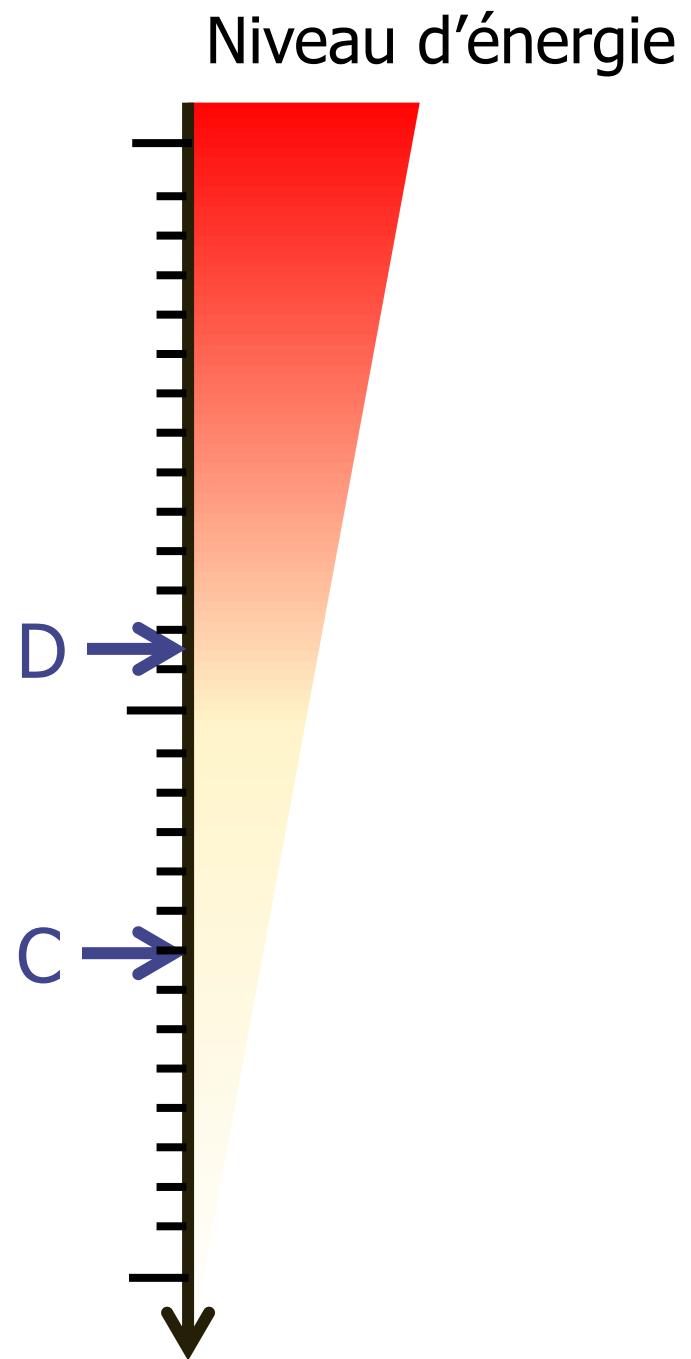
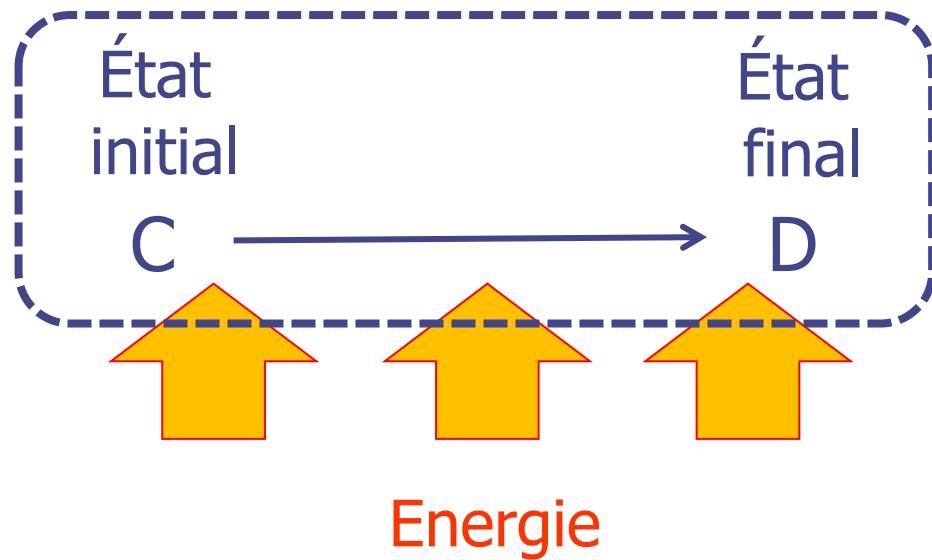
Niveau d'énergie

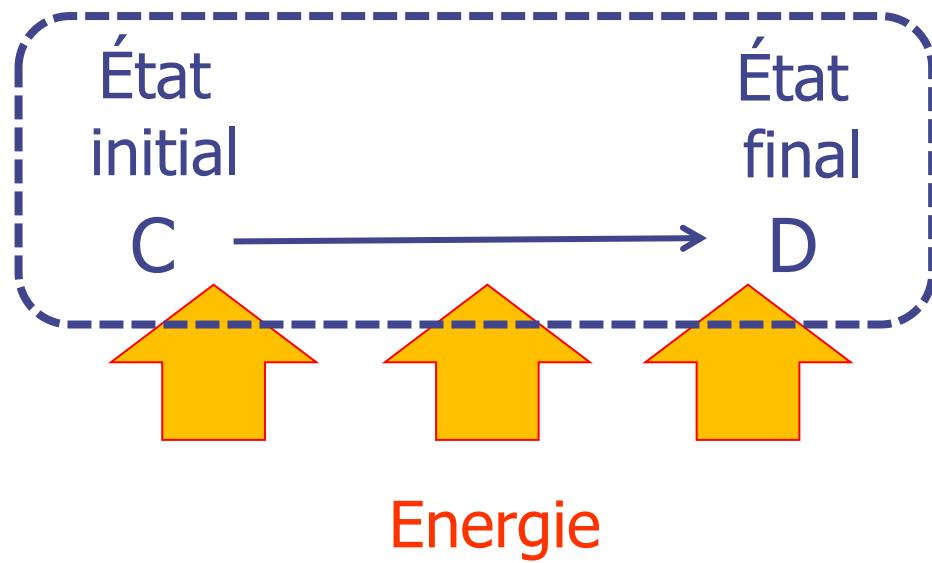




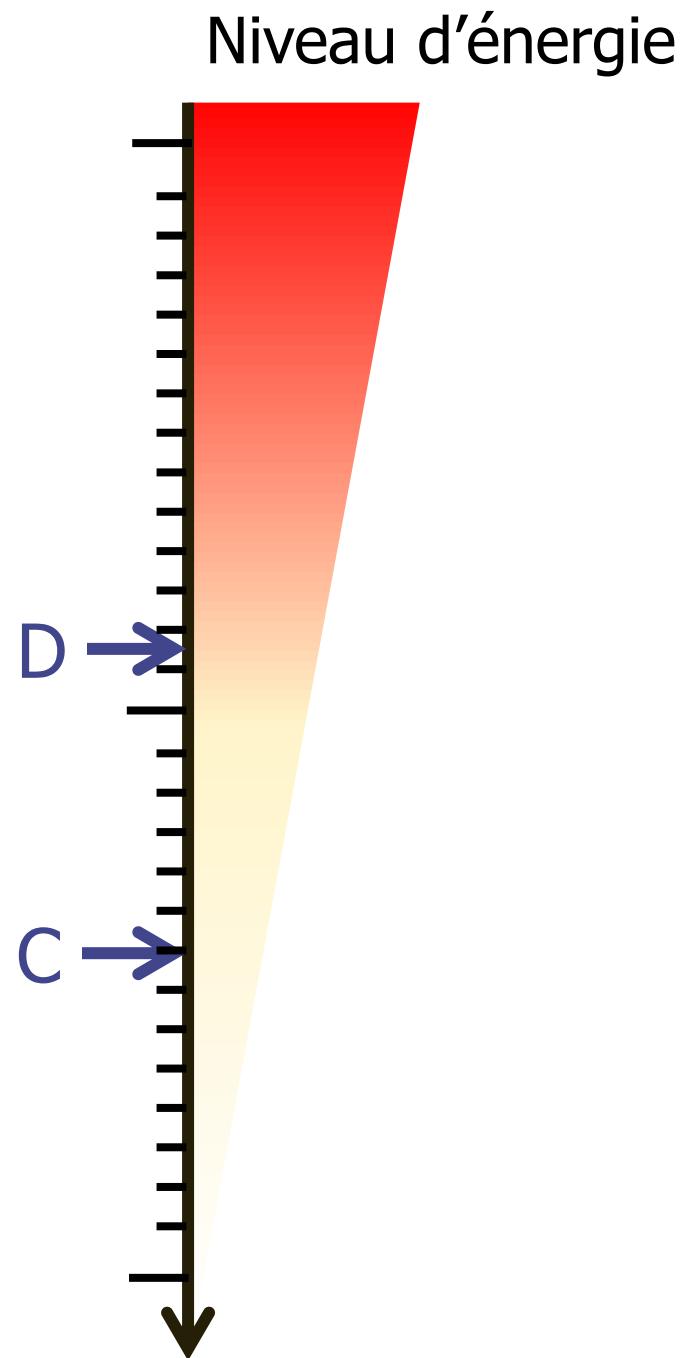
Spontanée ?







**Endergonique**  
**Endothermique**

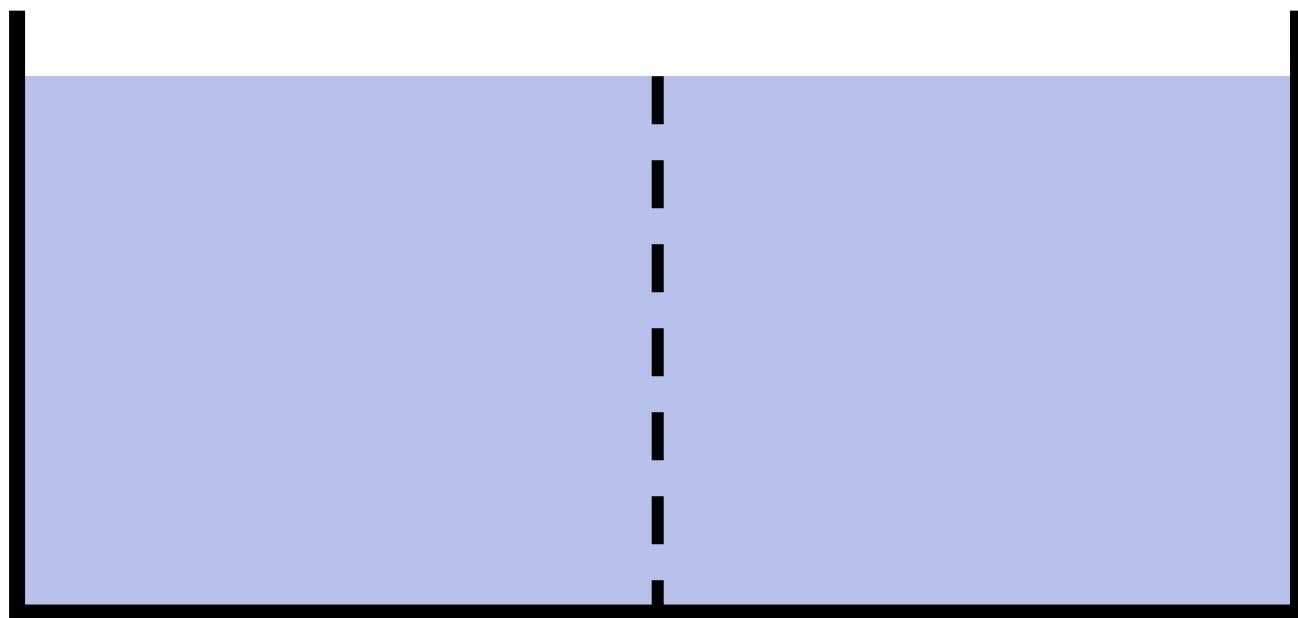


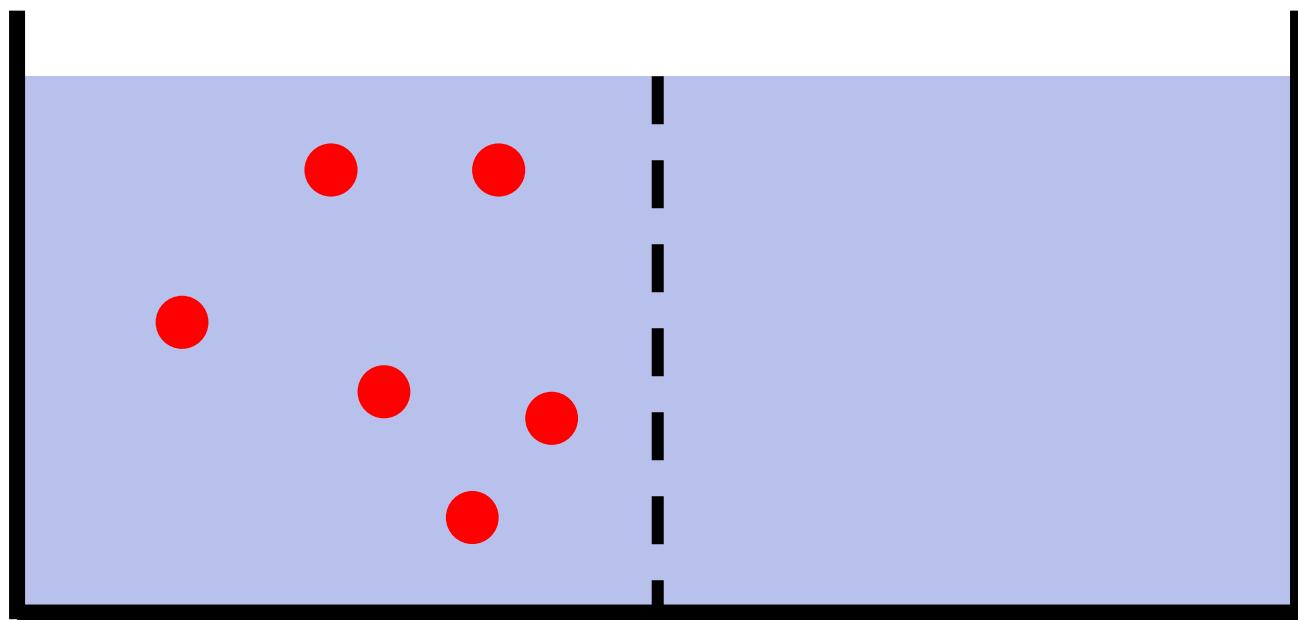
$\Delta G < 0$  (exergonique)

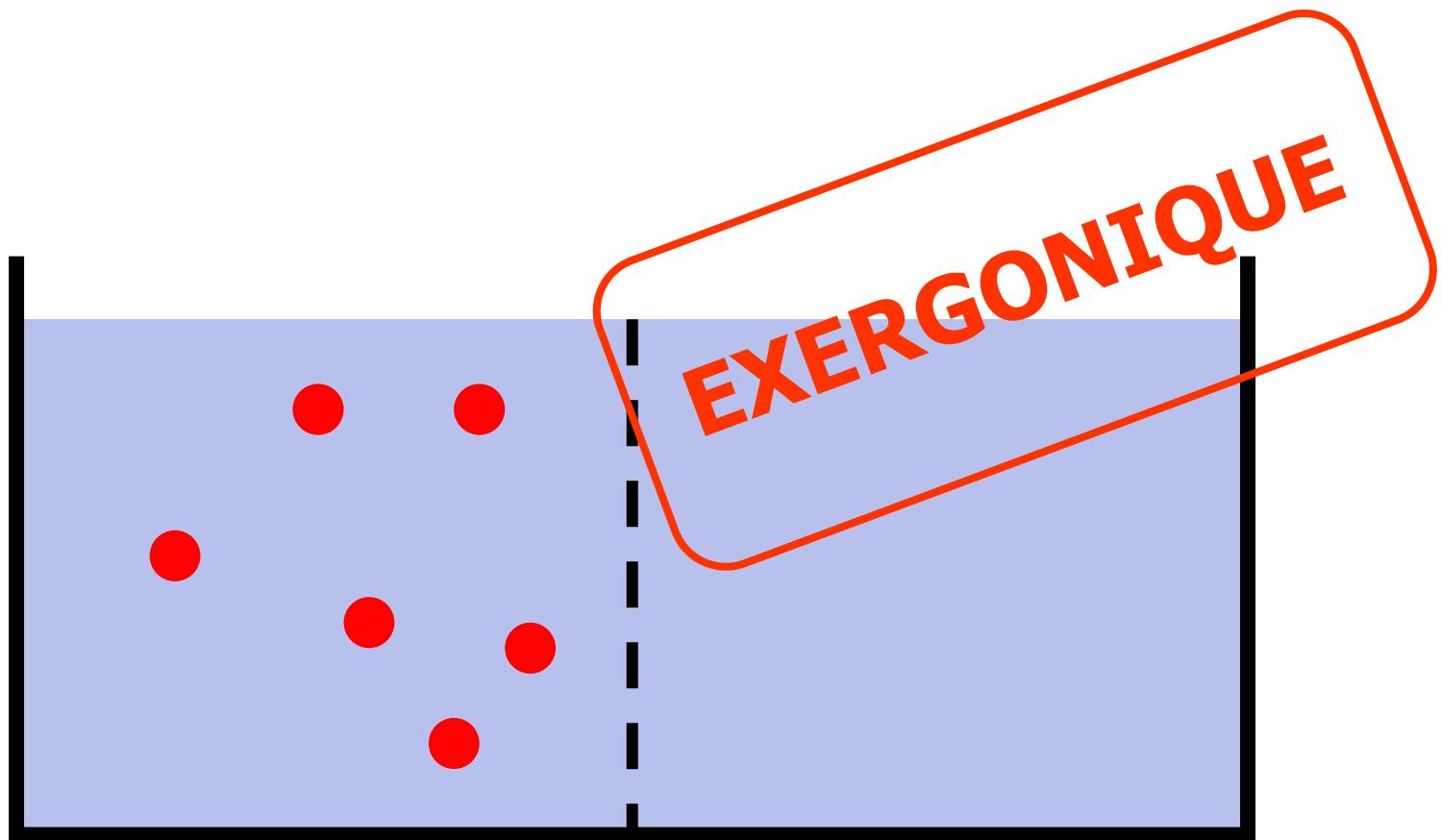
$\Delta G > 0$  (endergonique)

$\Delta G = 0$  (équilibre)

# QUIZ TIME !!







# Niveau d'énergie

Dans l'organisme

Molécules  
complexes

Catabolisme



# Niveau d'énergie

## Dans l'organisme

Molécules complexes

Molécules complexes

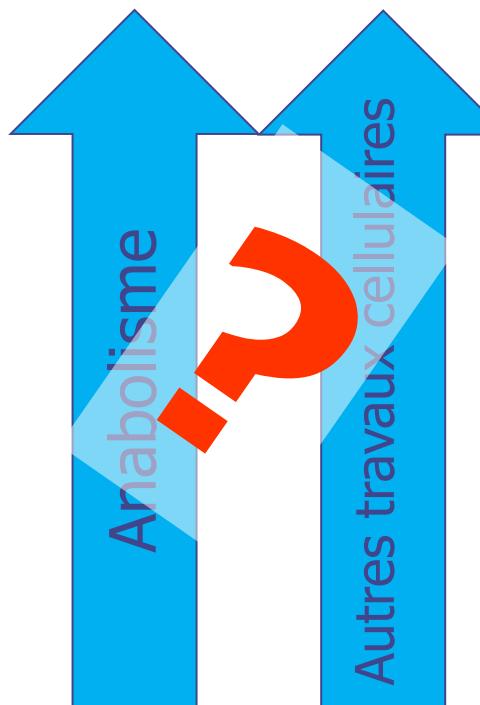
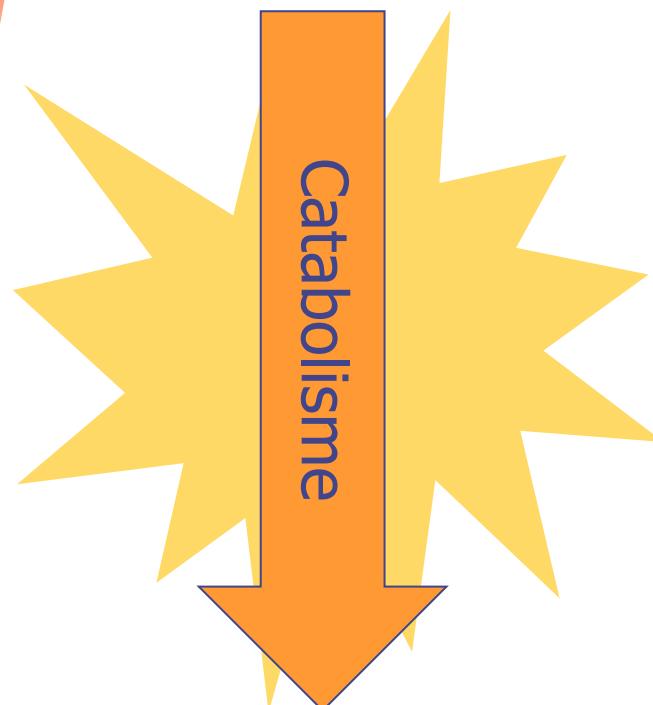
Catabolisme

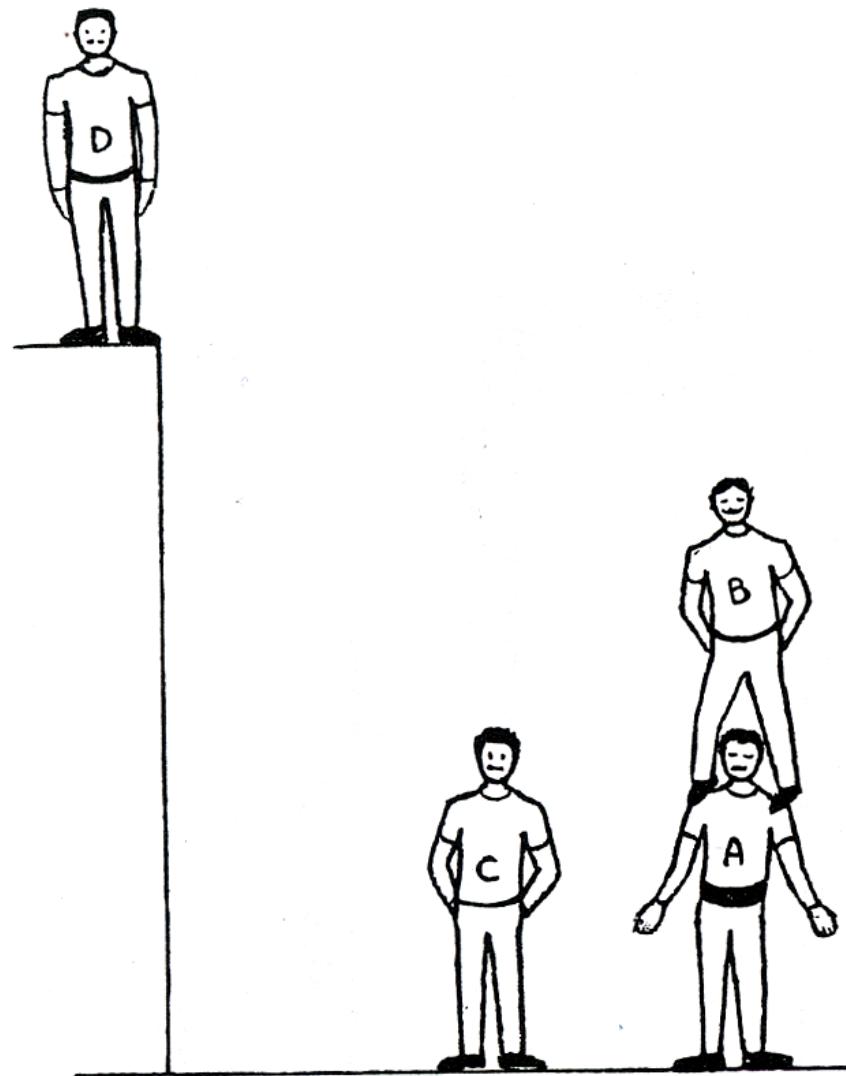
$\text{CO}_2 + \text{H}_2\text{O}$

Anabolisme

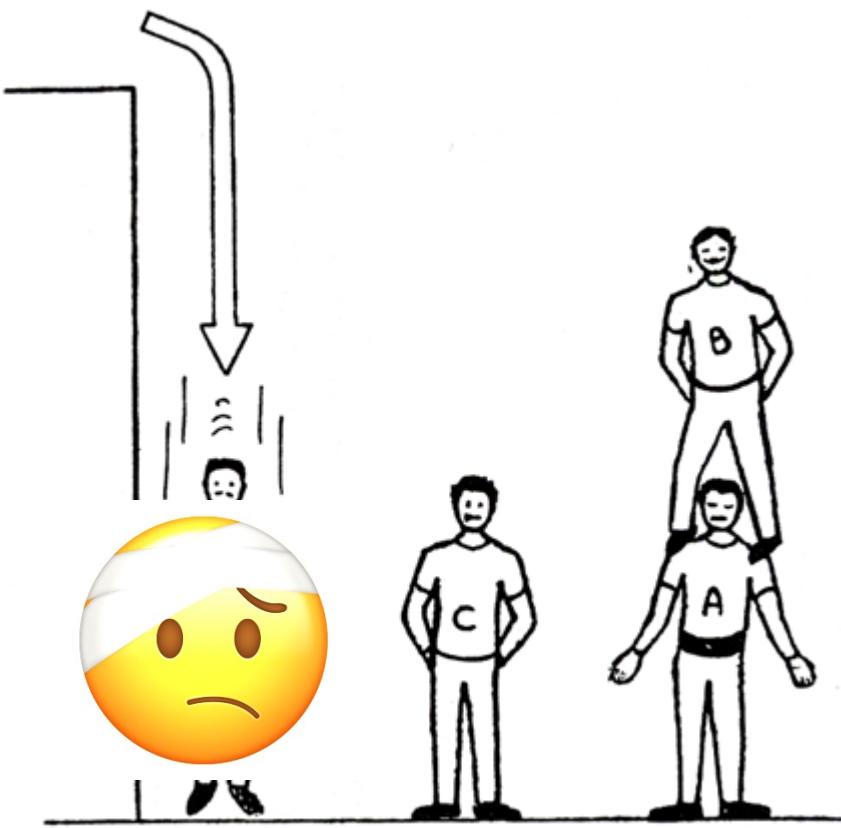
Autres travaux cellulaires

Précurseurs simples

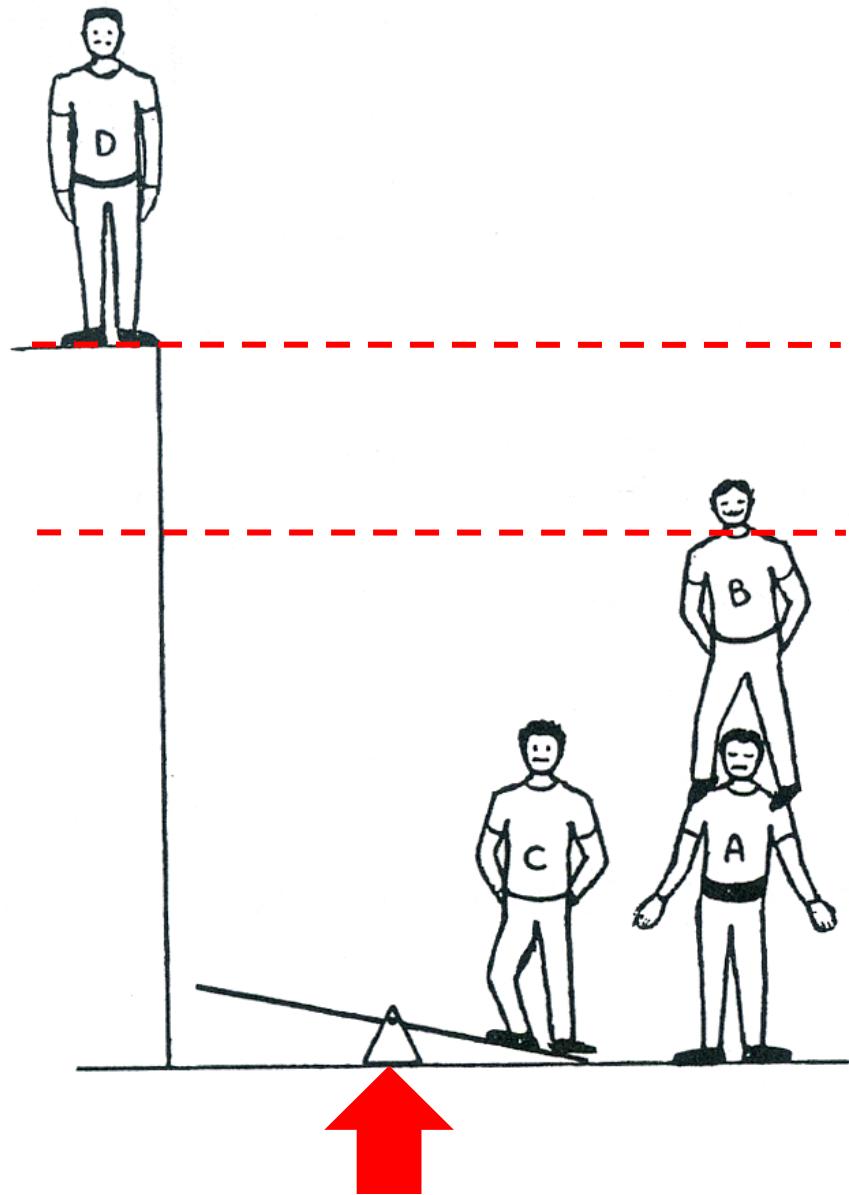




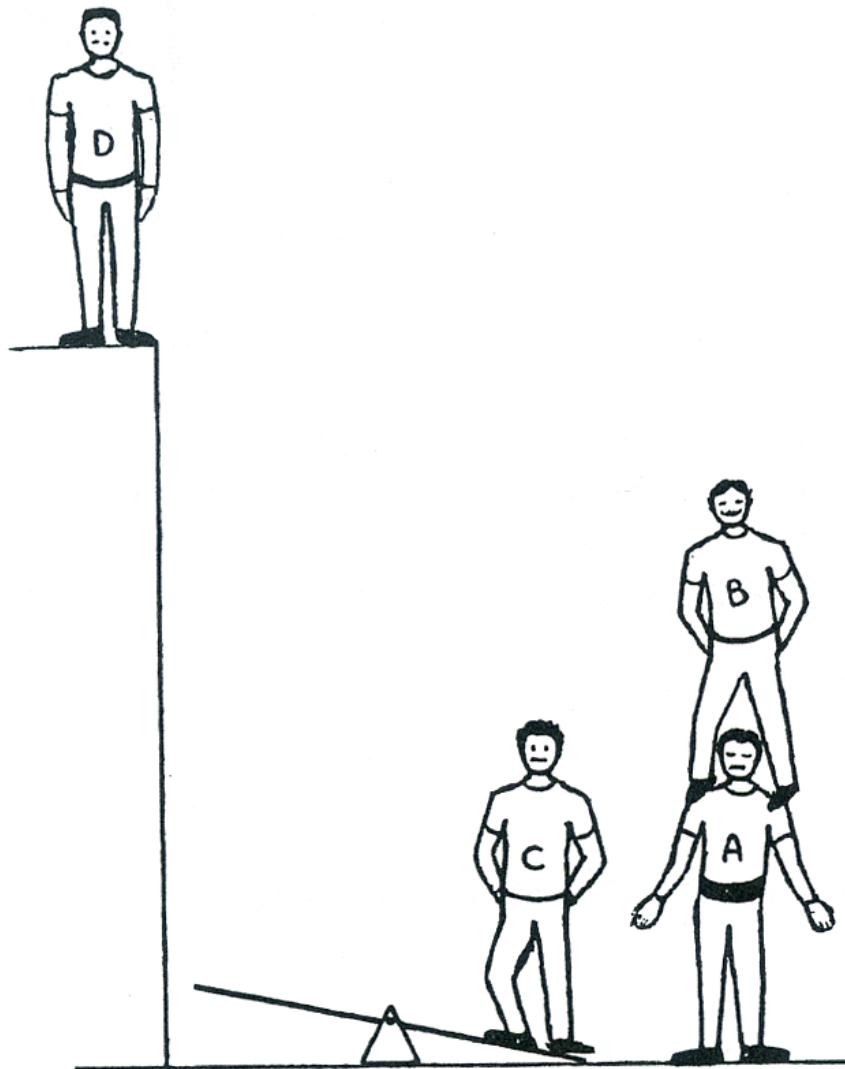
Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse



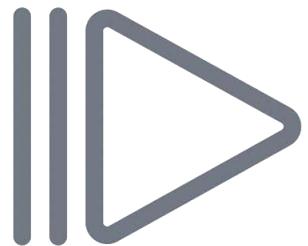
Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse



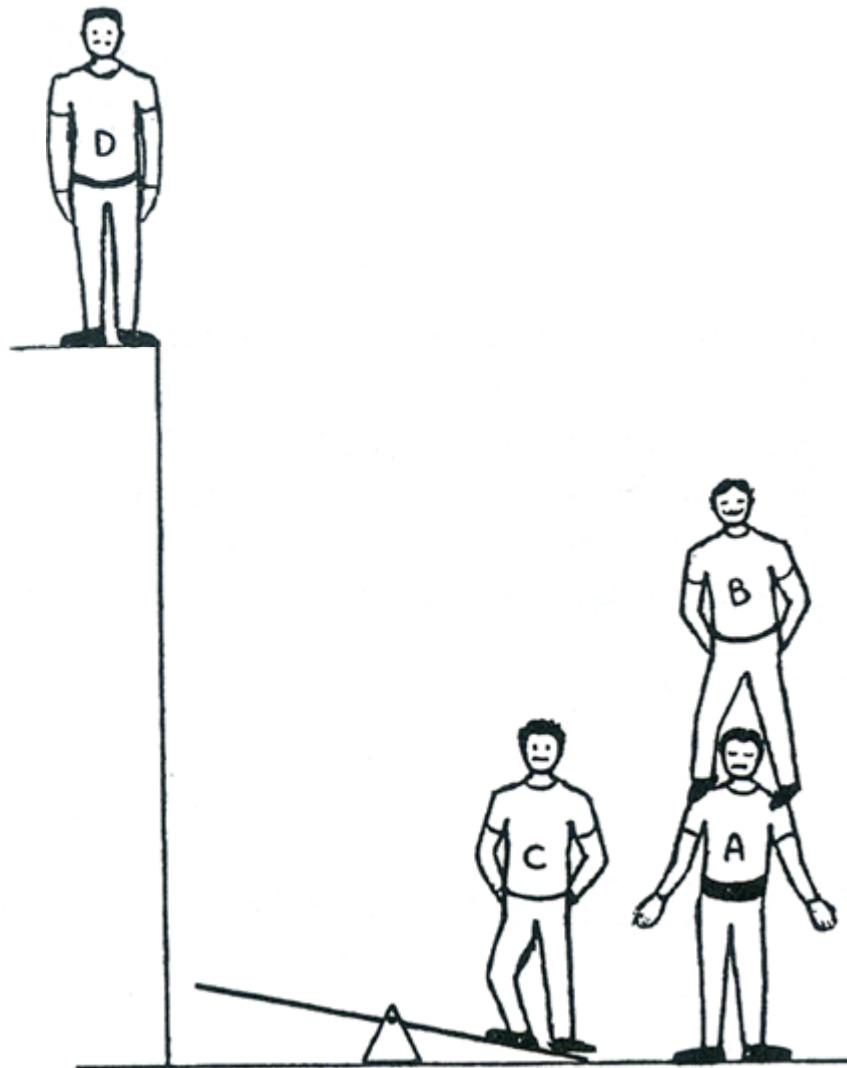
Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse



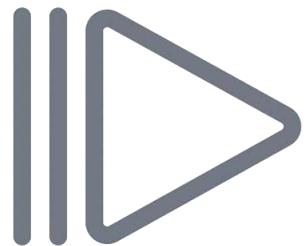
Slow motion



Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse

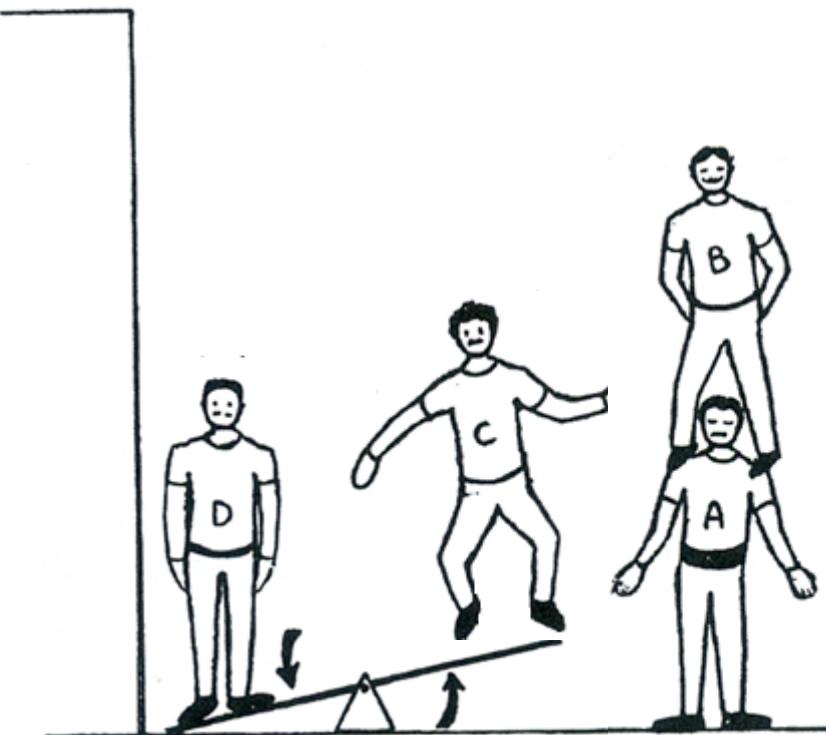
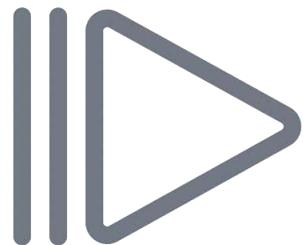


Slow motion



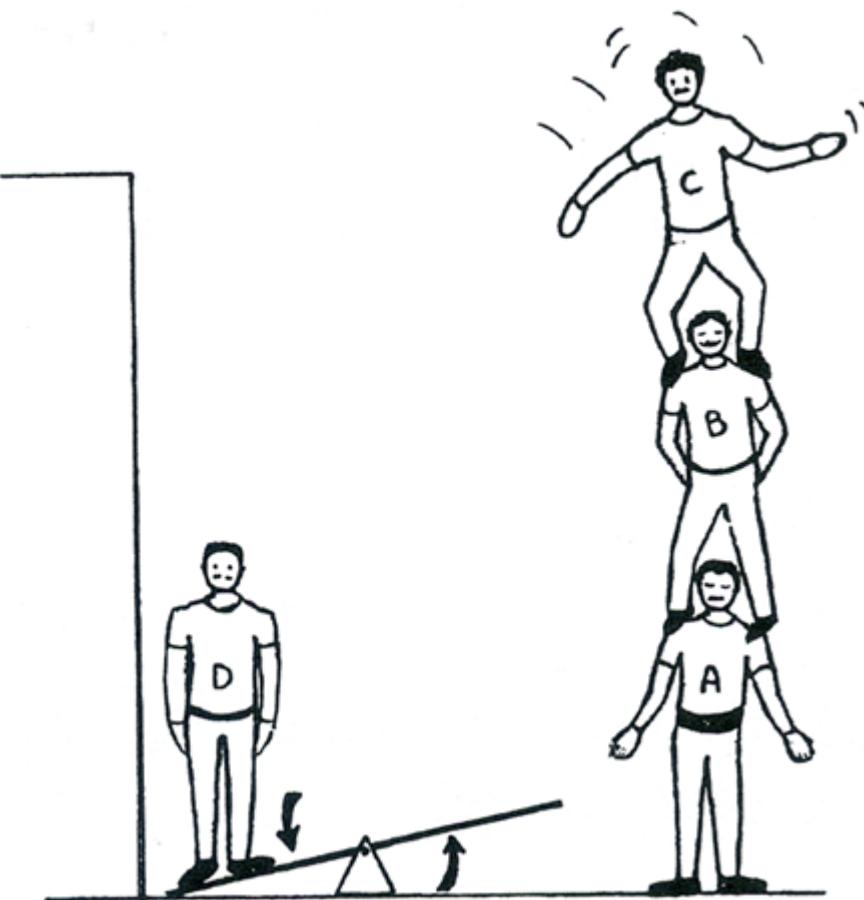
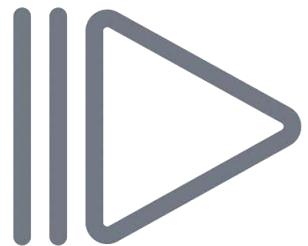
Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse

# Slow motion

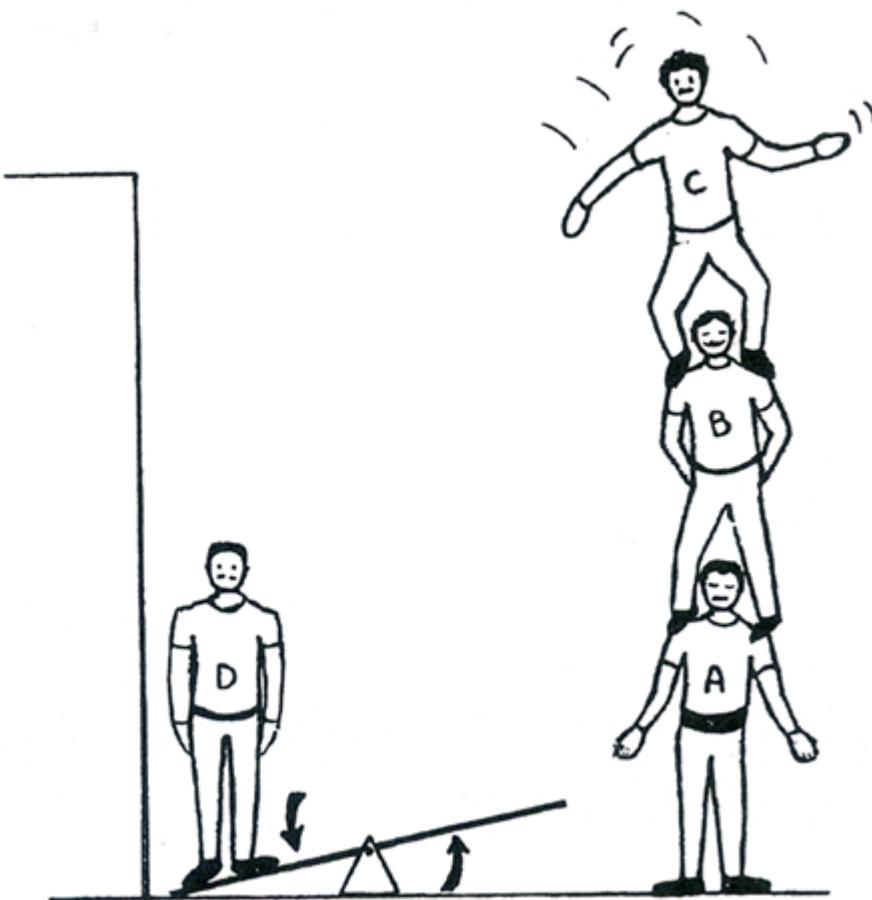


Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse

# Slow motion

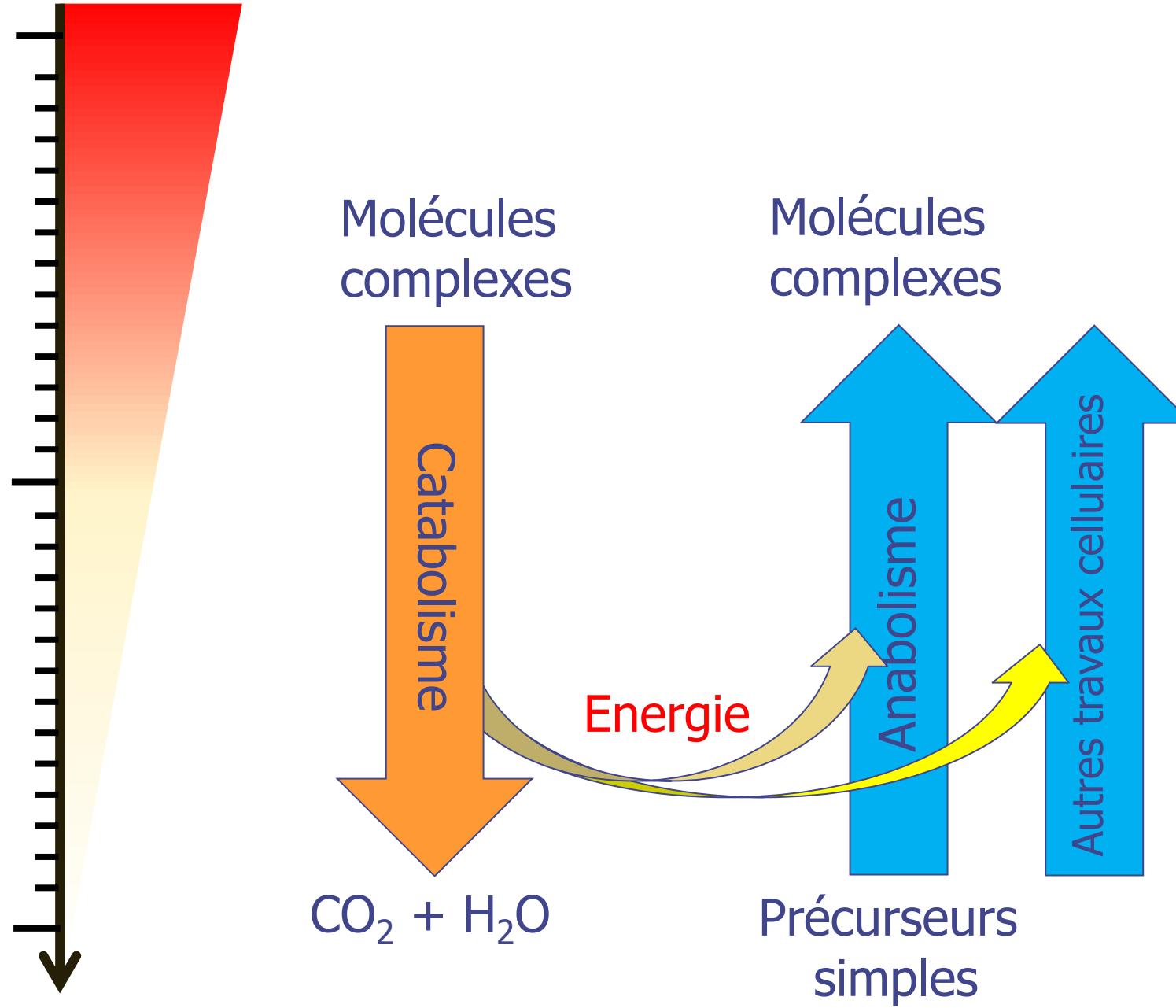


Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse



Bioénergétique cellulaire.  
J. J. Bernard. 2002. Ellipse

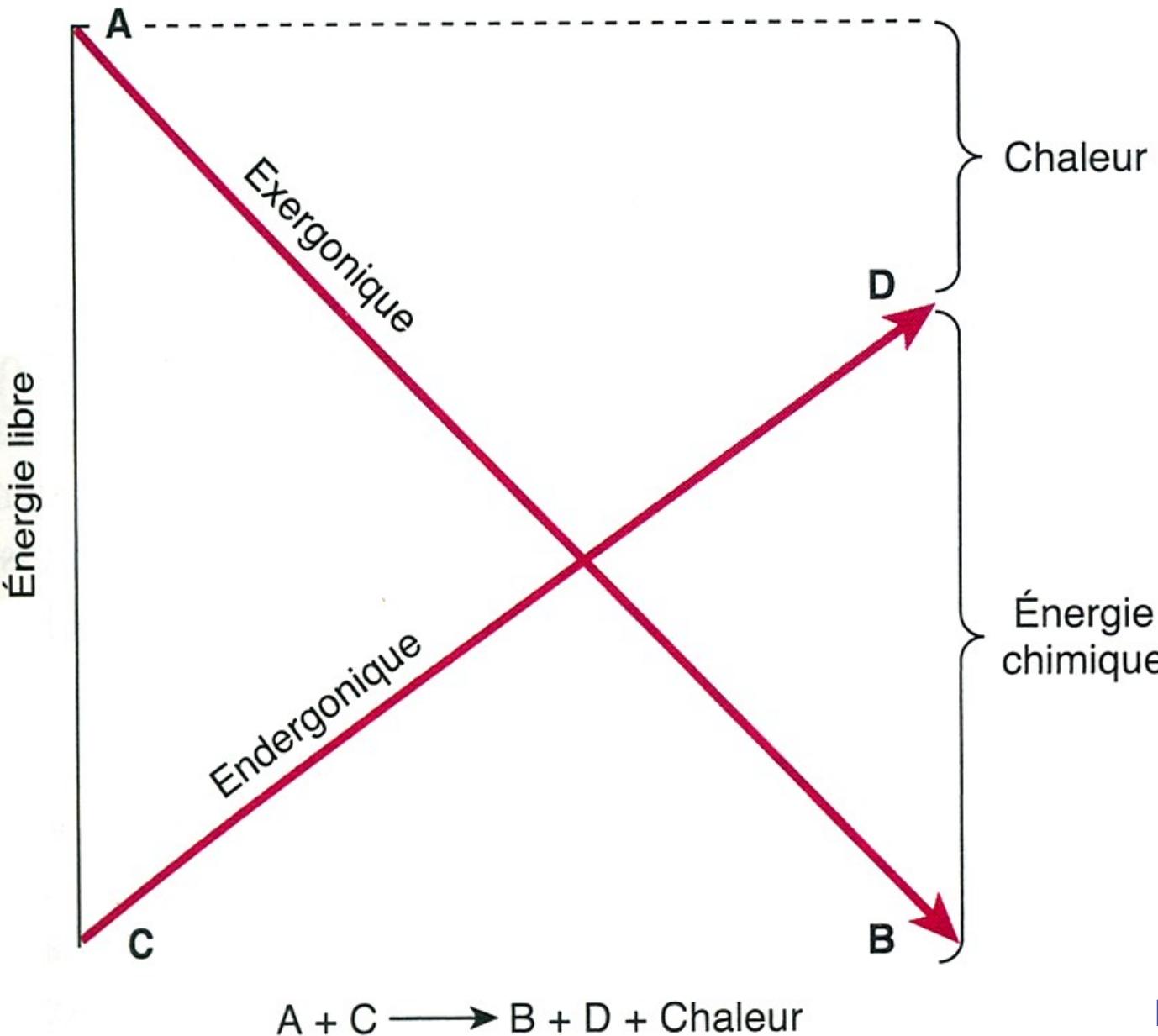
# Niveau d'énergie



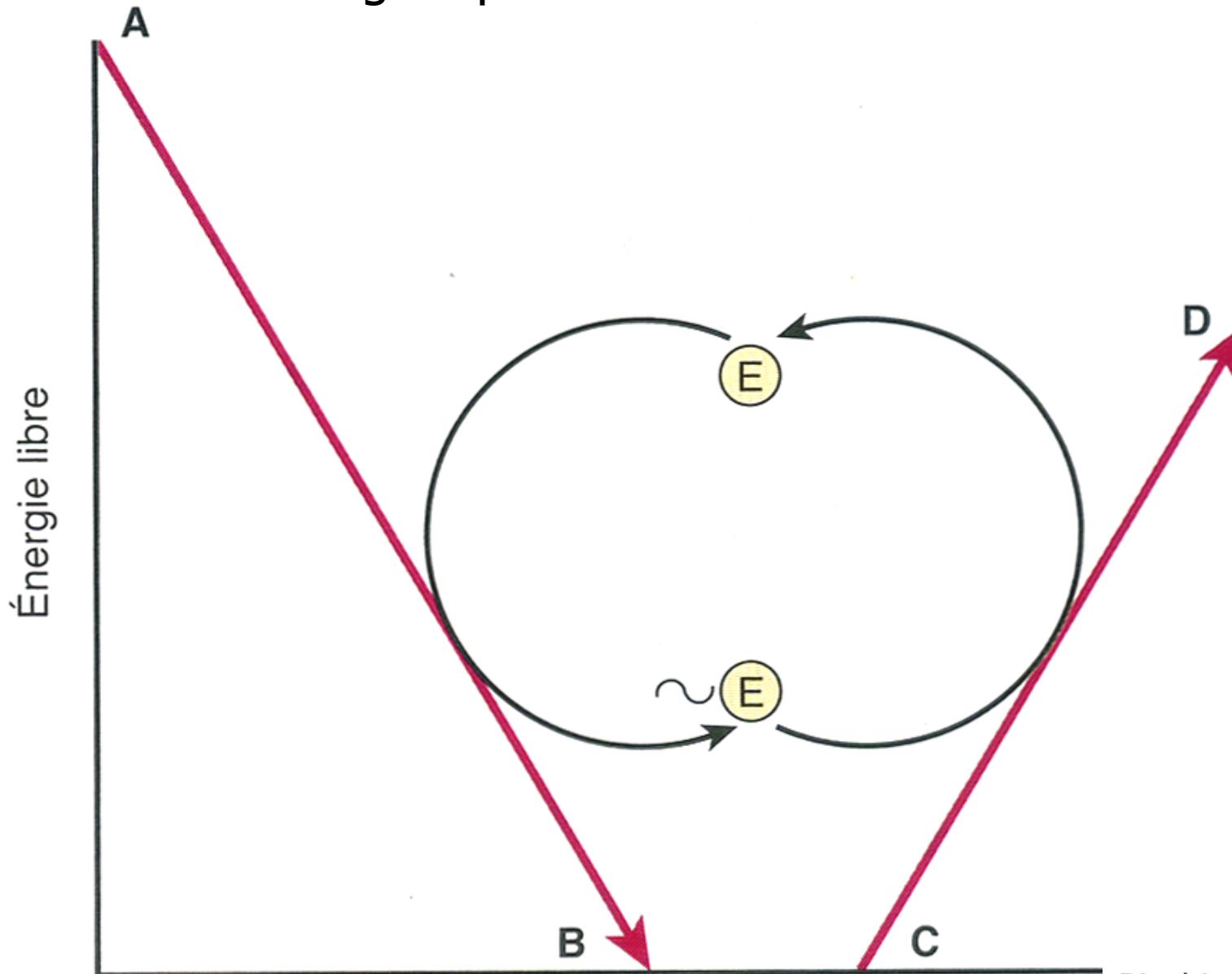
A close-up photograph of a bicycle's rear wheel and drivetrain. The wheel has a black tire with a brown tread pattern and a silver rim. The drivetrain consists of a black chain, a silver rear sprocket, and a black rear wheel hub. The bicycle frame is black. A large, semi-transparent watermark with the word "couplages" is overlaid on the image. The word is written in a white, sans-serif font, with the letter "S" in red. The watermark is oriented diagonally, following the curve of the bicycle's rear wheel.

couplages

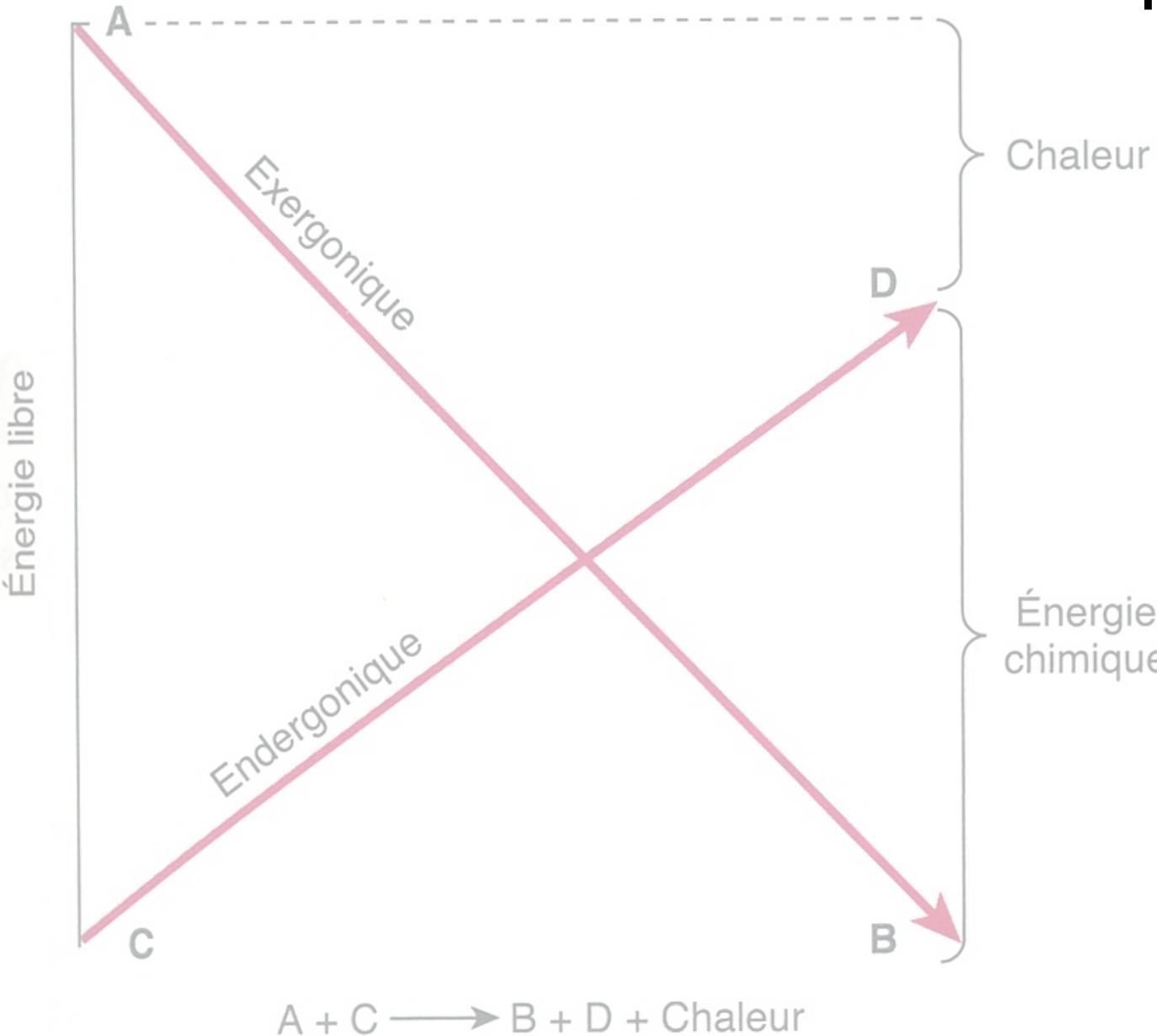
# Couplage d'une réaction Exergonique à une réaction Endergonique



# Transfert d'énergie libre d'une réaction exergonique à une réaction endergonique via un intermédiaire « riche en énergie »



# Couplage direct



# Réaction d'oxydo-réduction

Composé A  
réduit (agent  
réducteur)



Composé B  
oxydé  
(agent  
oxydant)



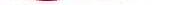
A est oxydé, perdant  
des électrons.

B est réduit, gagnant  
des électrons.

Composé A  
oxydé



Composé B  
réduit



$A/A^{2e^-}$  et  $B/B^{2e^-}$  sont deux COUPLES RÉDOX

# Réaction d'oxydo-réduction

Composé A  
réduit (agent  
réducteur)



Composé B  
oxydé  
(agent  
oxydant)



# Réaction d'oxydo-réduction

Composé A  
réduit (agent  
réducteur)



Composé B  
oxydé  
(agent  
oxydant)

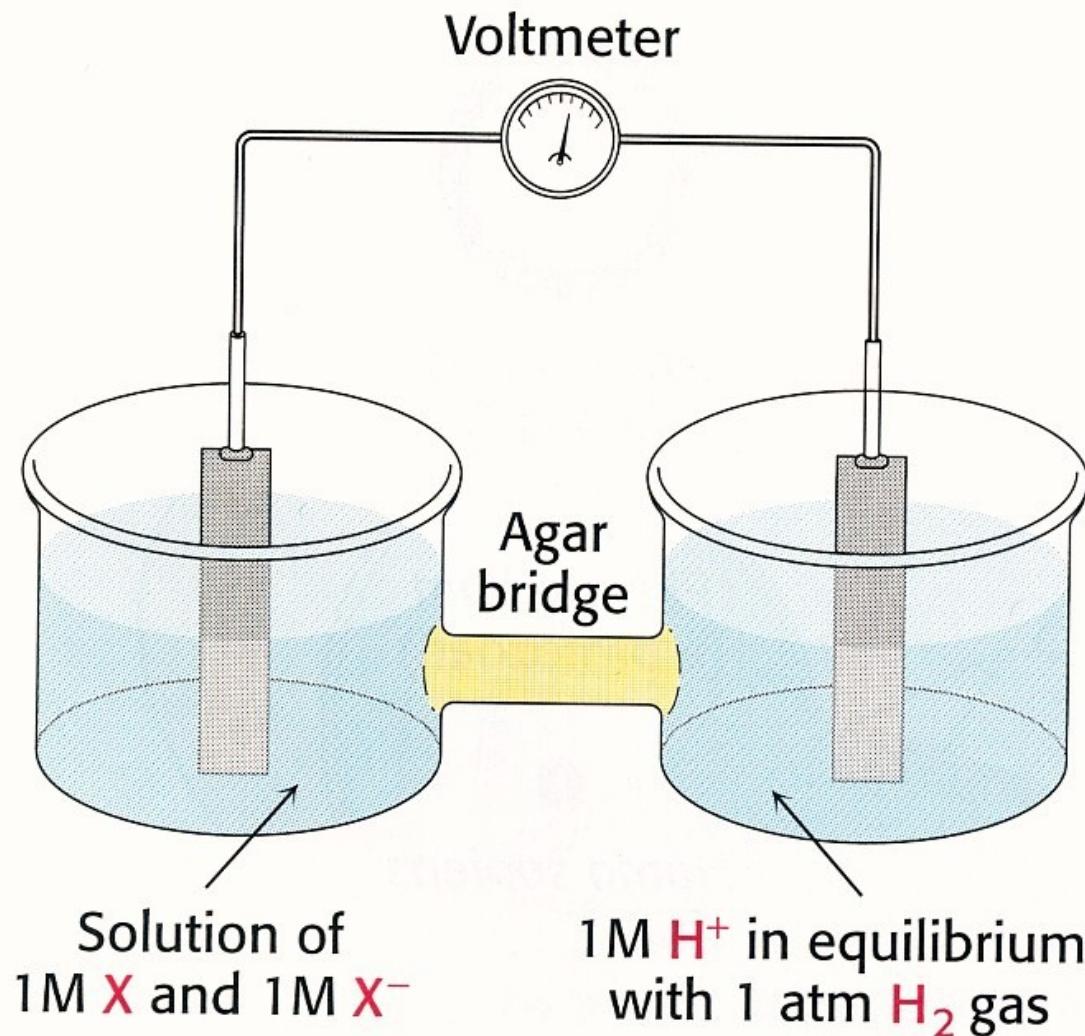


2 couples rédox en solution : il peut y avoir transfert spontané du donneur du couple A vers l'accepteur du couple B si **l'affinité** de l'accepteur de B pour les électrons est supérieure à celle de A

Donneur ( $A_{\text{red}}$ ) et accepteur ( $B_{\text{ox}}$ ) en quantités équimolaires

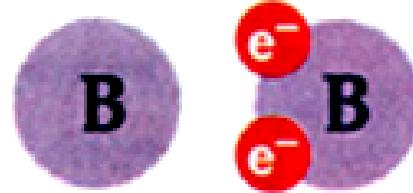


# Détermination des POTENTIELS REDOX



# Exemples de POTENTIELS REDOX

Système	$E'_0$ Volts
$\text{H}^+/\text{H}_2$	– 0,42
$\text{NAD}^+/\text{NADH}$	– 0,32
Lipoate; oxydé/réduit	– 0,29
Acétoacétate/3-hydroxybutyrate	– 0,27
Pyruvate/lactate	– 0,19
Oxaloacétate/malate	– 0,17
Fumarate/succinate	+ 0,03
Cytochrome <i>b</i> ; $\text{Fe}^{3+}/\text{Fe}^{2+}$	+ 0,08
Ubiquinone; ox/red	+ 0,10
Cytochrome <i>c</i> <sub>1</sub> ; $\text{Fe}^{3+}/\text{Fe}^{2+}$	+ 0,22
Cytochrome <i>a</i> ; $\text{Fe}^{3+}/\text{Fe}^{2+}$	+ 0,29
Oxygène/eau	+ 0,82



Couple A/A<sup>2-</sup>

$$E'_0(A) = - 0,60 \text{ (V)}$$

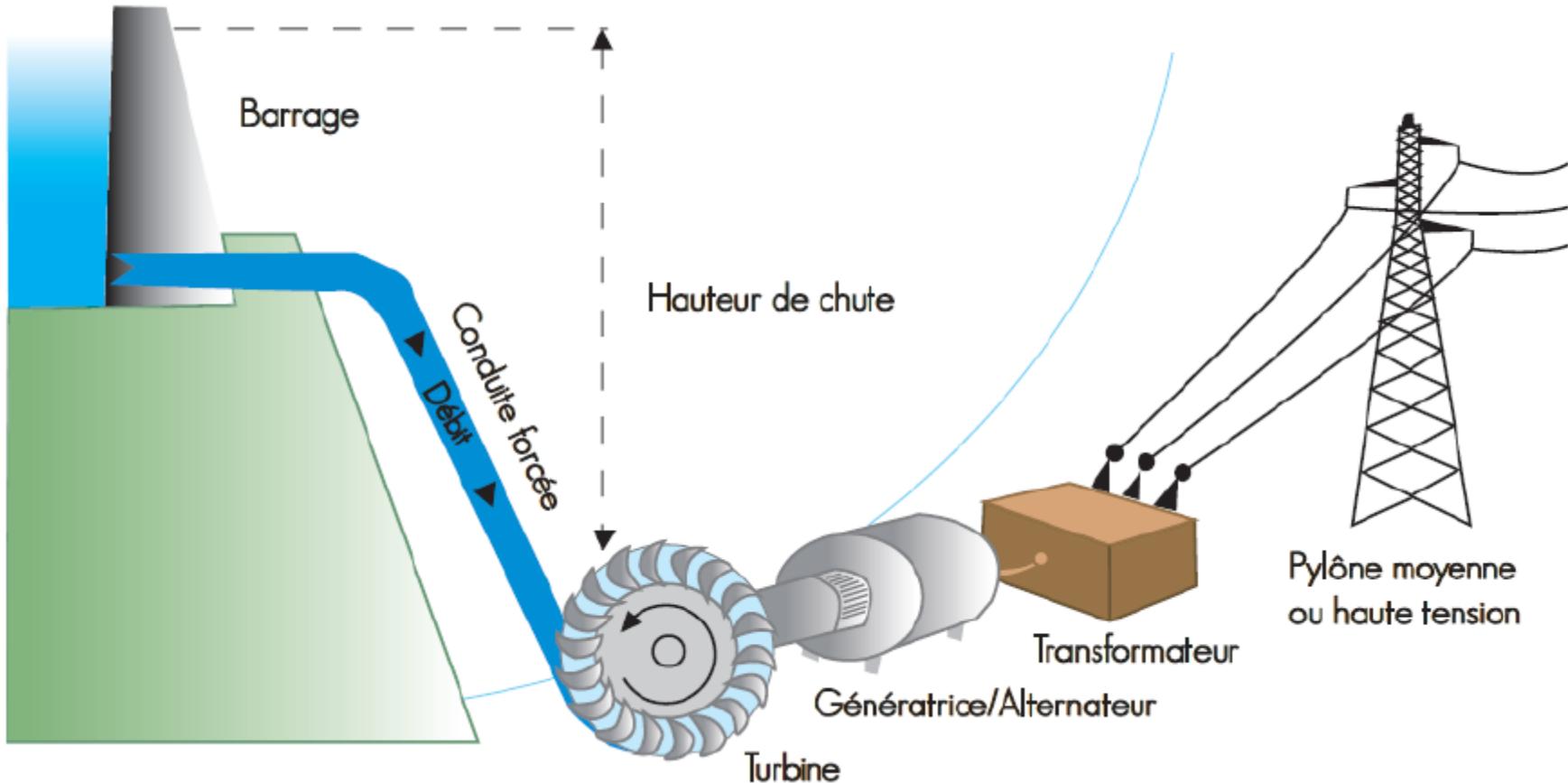
Couple B/B<sup>2-</sup>

$$E'_0(B) = - 0,20 \text{ (V)}$$

Différence de potentiel  $\Delta E'_0 = - 0,20 - (- 0,60) = + 0,4 \text{ (V)}$

## Exemples de POTENTIELS REDOX

Système	$E'_0$ Volts
$\text{H}^+/\text{H}_2$	– 0,42
$\text{NAD}^+/\text{NADH}$	– 0,32
Lipoate; oxydé/réduit	– 0,29
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Cytochrome <i>a</i> ; $\text{Fe}^{3+}/\text{Fe}^{2+}$	+ 0,29
Oxygène/eau	+ 0,82

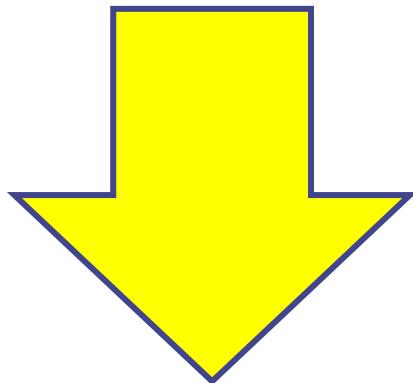
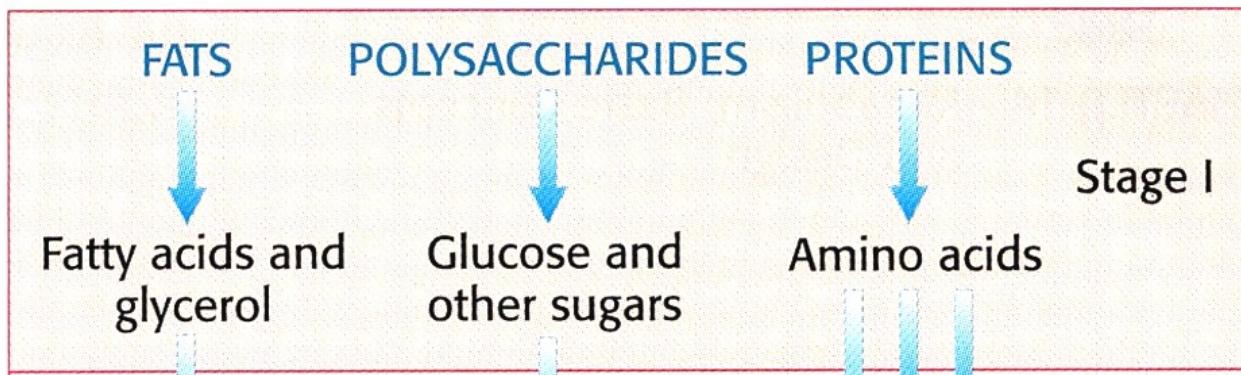


Il est possible de calculer la quantité d 'énergie fournie par le flux d'électron :

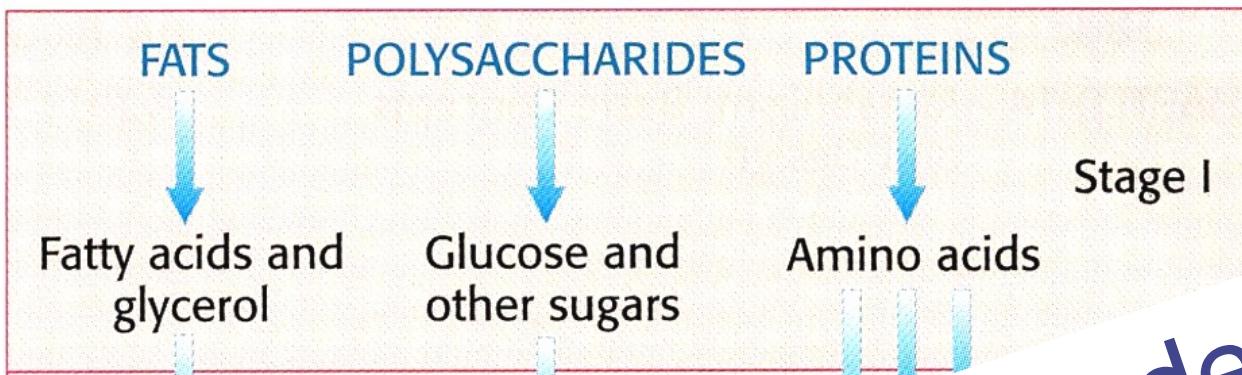
$$\Delta G^0' = - n \cdot F \cdot \Delta E'_0$$

Ou **n** : nombre d'électrons transférés; **F** : cte de *Faraday*

La différence de potentiel électrique est à l'origine de l'énergie libre cellulaire



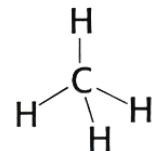
# ENERGIE



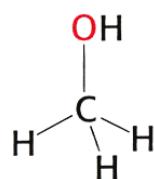
Peuvent s'engager dans des  
transformations EXERGONIQUES

# ENERGIE

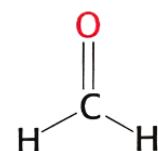
most energy → least energy



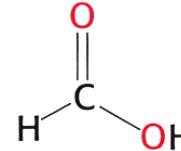
**Methane**



**Methanol**



**Formaldehyde**



**Formic acid**



**Carbon dioxide**

$\Delta G^0$  oxydation  
(Kcal mol<sup>-1</sup>)

-196

-168

-125

-68

0

$\Delta G^0$  oxydation  
(KJ mol<sup>-1</sup>)

-820

-703

-523

-285

0

## Energie libre d'oxydation de composés mono-carbonés

Biochemistry.

Fifth edition. 2002. Freeman and Co.

# Exemple de carbone réduit alimentaire : Glucose

Oxydation complète du glucose



$\Delta G'^0 = - 2600 \text{ KJ/mole}$