Resolución de ejercicio síntesis de ATP

14. Daily ATP Utilization by Human Adults

(a) A total of 30.5 kJ/mol of free energy is needed to synthesize ATP from ADP and P_i when the reactants and products are at 1 M concentrations (standard state). Because the actual physiological concentrations of ATP, ADP, and P_i are not 1 M, the free energy required to synthesize ATP under physiological conditions is different from $\Delta G'^{\circ}$. Calculate the free energy required to synthesize ATP in the human hepatocyte when the physiological concentrations of ATP, ADP, and P_i are 3.5, 1.50, and 5.0 mM, respectively.

(b) A 68 kg (150 lb) adult requires a caloric intake of 2,000 kcal (8,360 kJ) of food per day (24 h). The food is metabolized and the free energy is used to synthesize ATP, which then provides energy for the body's daily chemical and mechanical work. Assuming that the efficiency of converting food energy into ATP is 50%, calculate the weight of ATP used by a human adult in 24 h. What percentage of the body weight does this represent?

(c) Although adults synthesize large amounts of ATP daily, their body weight, structure, and composition do not change significantly during this period. Explain this apparent contradiction.

Lehninger, Biochemistry

Resolución del problema

(a) A total of 30.5 kJ/mol of free energy is needed to synthesize ATP from ADP and P_i when the reactants and products are at 1 M concentrations (standard state). Because the actual physiological concentrations of ATP, ADP, and P_i are not 1 M, the free energy required to synthesize ATP under physiological conditions is different from $\Delta G'^{\circ}$. Calculate the free energy required to synthesize ATP in the human hepatocyte when the physiological concentrations of ATP, ADP, and P_i are 3.5, 1.50, and 5.0 mM, respectively.

A) $$\Delta G = \Delta G^{\circ} + RT \ln \frac{[C][D]}{[A][B]}$$

ΔG°= 30.5 KJ/mol

ATP [C]= 3.5 mM

ADP [A]= 1.5 mM

Fosfato[B]= 5mM

T= 37°C=37+273.15= 310.15K

R=8.31 J/mol K

ΔG=?

$$Keq = \frac{0.0035}{(0.0015*0.005)} = 466.66$$

ΔG= 30.5kJ/mol + 0.00831KJ/molK (310.15K) ln 466.66

ΔG= 30.5 kJ/mol + 15.8393 = 34.46 KJ/mol

(b) A 68 kg (150 lb) adult requires a caloric intake of 2,000 kcal (8,360 kJ) of food per day (24 h). The food is metabolized and the free energy is used to synthesize ATP, which then provides energy for the body's daily chemical and mechanical work. Assuming that the efficiency of converting food energy into ATP is 50%, calculate the weight of ATP used by a human adult in 24 h. What percentage of the body weight does this represent?

- 8,360 kJ = 4180 kJ
- 2
- 1mol ATP — 46.33 kJ
- x — 4180 kJ
- 90.22 mol ATP
- ATP 507.18 g — 1 mol
- x — 90.22 mol
- 45758.95g= 45.75kg ATP

(c) Although adults synthesize large amounts of ATP daily, their body weight, structure, and composition do not change significantly during this period. Explain this apparent contradiction.

- En un organismo hay aproximadamente **50 g de ATP**.
- Entonces si se necesitan **45.75kg** ATP al día, los 50 g de ATP se tiene que que reciclar (remover el fosfato terminal y volver a formar el enlace con el tercer fosfato) alrededor de **915** veces al día

Usos del ATP

Importancia de la producción de ATP

Uso de inhibidor de la síntesis de ATP por la ATPasa

No hay cambio significativo en los niveles de ATP, debido a la edad y a la ingesta calórica

Drew, Barry and Christiaan Leeuwenburgh. Method for measuring ATP production in isolated mitochondria: ATP production in brain and liver mitochondria of Fischer-344 rats with age and caloric restriction. *Am J Physiol Regul Integr Comp Physiol* 285: R1259–R1267, 2003; 10.1152/ajpregu.00264.2003.—The production of ATP is vital for muscle contraction, chemiosmotic homeostasis, and normal cellular function. Many studies have measured ATP content or qualitative changes in ATP production, but few have quantified ATP production in vivo in isolated mitochondria. Because of the importance of understanding the energy capacity of mitochondria in biology, physiology, cellular dysfunction, and ultimately, disease pathologies and normal aging, we modified a commercially available bioluminescent ATP determination assay for quantitatively measuring ATP content and rate of ATP production in isolated mitochondria. The bioluminescence assay is based on the reaction of ATP with recombinant firefly luciferase and its substrate luciferin. The stabilities of the reaction mixture as well as relevant ATP standards were quantified. The luminescent signals of the reaction mixture and a 0.5 μM ATP standard decreased linearly at rates of 2.16 and 1.39% decay/min, respectively. For a 25 μM ATP standard, the luminescent signal underwent a logarithmic decay, due to intrinsic deviations from the Beer-Lambert law. Moreover, to test the functionality of isolated mitochondria, they were incubated with 1 and 5 mM oligomycin, an inhibitor of oxidative phosphorylation. The rate of ATP production in the mitochondria declined by 34 and 83%, respectively. Due to the sensitivity and stability of the assay and methodology, we were able to quantitatively measure in vivo the effects of age and caloric restriction on the ATP content and production in isolated mitochondria from the brain and liver of young and old Fischer-344 rats. In both tissues, neither age nor caloric restriction had any significant effect on the ATP content or the rate of ATP production. This study introduces a highly sensitive, reproducible, and quick methodology for measuring ATP in isolated mitochondria.

ATP en humanos

La energía libre de la hidrólisis de ATP

CONCENTRACIONES DE ALGUNOS METABOLITOS

	ATP	ADP[a]	AMP	Pi	PCr
Hepatocito de rata	3.38	1.32	0.29	4.8	0
Miocito de rata	8.05	0.93	0.04	8.05	28
Neurona de rata	2.59	0.73	0.06	2.72	4.7
Eritrocito humano	2.25	0.25	0.02	4.65	0
Escherichia coli	7.90	1.04	0.82	7.9	0

GASTO METABÓLICO

Según los datos del artículo de revisión de Rolfe y Brown (1997), la participación de los diferentes procesos en la TMB es porcentualmente como sigue:

- Síntesis de proteínas	25 a 30%
- ATPasa Na^+/K^+	19 a 28%
- ATPasa Ca^{2+}	4 a 8%
- ATPasa de la actomiosina	2 a 8%
-Gluconeogénesis	3%
- Otras (síntesis de RNA y DNA; ciclos de sustrato; escape de protones).	No definido

Producción de ATP

La energía libre estándar (ΔGº) para la hidrólisis del ATP a ADP y Pi medida in vitro es de -7.3 Cal/mol, pero bajo las condiciones de las células de un homeotermo DG podría llegar a -12.5 Cal/mol (Lehninger, p. 413). En la Tabla 2.3, adaptada de Ferrannini (1988) se presenta la relación ATP/O_2 para los tres grupos de combustibles:

Tabla 2.3. Utilización de oxígeno y producción de energía y de ATP de los tres grupos de combustibles

Combustible oxidado (1 mol)	ΔGº (Cal/mol)	O_2 utilizado (moles)	Producción ATP (moles)	ATP/O_2 (mol/mol)
Glucosa	-673	6	36	6
Palmitato	-2398	23	129	5.6
Amoniácidos*	-475	5.1	23	4.5

* La oxidación completa de 1 mol de aminoácidos lleva a la síntesis de 28.8 moles de

Energy Charge of a Cell

$$\underline{\text{Energy Charge}} = \frac{ATP + \frac{1}{2}\,ADP}{ATP + ADP + AMP}$$

Limits are 0 and 1.0

If all is ATP, the energy charge = 1
If all is AMP, the energy charge = 0

ATP can be regenerated using adenylate kinase (this is a nucleoside monophosphate kinase):

2 ADP <===> ATP + AMP

Rate vs Energy Charge

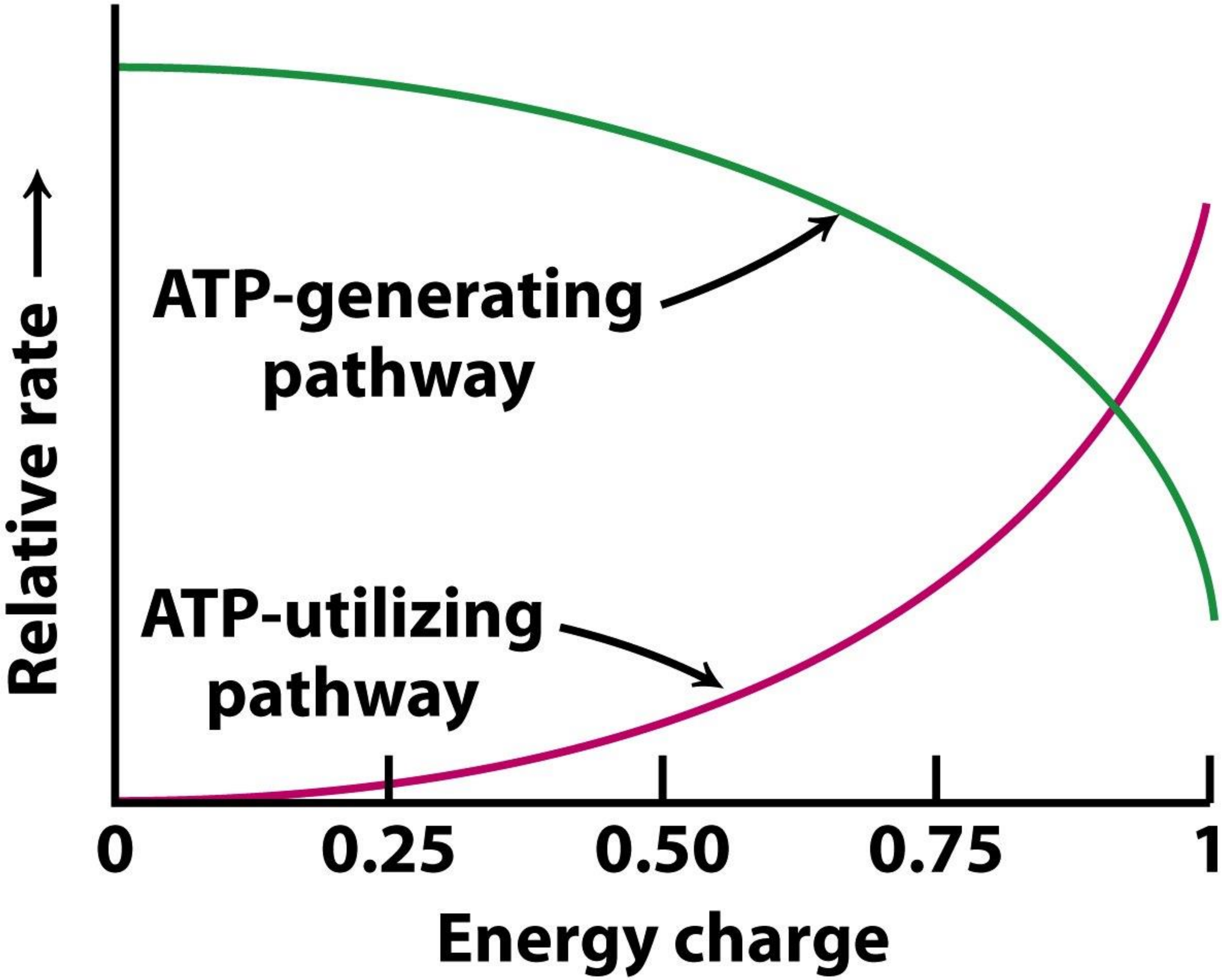

Figure 15-19
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