Modelo de fotossíntese de Farquhar

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Velocidade da reação

$$\mathrm{E} + \mathrm{S} \underset{k_2}{\overset{k_1}{\rightleftharpoons}} \mathrm{ES} \xrightarrow{k_3} \mathrm{E} + \mathrm{P}$$

Denning (1993)

Velocidade da reação

$$\mathrm{E} + \mathrm{S} \underset{k_2}{\overset{k_1}{\rightleftarrows}} \mathrm{ES} \xrightarrow{k_3} \mathrm{E} + \mathrm{P}$$

$$\frac{d[ES]}{dt} = k_1[E][S] - (k_2 + k_3)[ES]$$

Denning (1993)

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$$\frac{d[ES]}{dt} = k_1[E][S] - (k_2 + k_3)[ES]$$

$$[ES] = \frac{[E][S]}{\frac{k_2+k_3}{k_1}}$$

Denning (1993)

Velocidade da reação

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$$\frac{d[ES]}{dt} = k_1[E][S] - (k_2 + k_3)[ES]$$

$$[ES] = \frac{[E][S]}{\frac{k_2+k_3}{k_1}} = \frac{[E][S]}{K_M}$$

Constante de Michaelis $= K_M = \frac{k_2+k_3}{k_1}$

Denning (1993)

Velocidade da reação

$$\mathrm{E} + \mathrm{S} \underset{k_2}{\overset{k_1}{\rightleftarrows}} \mathrm{ES} \xrightarrow{k_3} \mathrm{E} + \mathrm{P}$$

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$$\text{Constante de Michaelis} = K_M = \frac{k_2+k_3}{k_1}$$

$$V = V_{max} \times \frac{[S]}{[S]+K_M}$$

Denning (1993)

Velocidade da reação

$$\mathrm{E} + \mathrm{S} \underset{k_2}{\overset{k_1}{\rightleftarrows}} \mathrm{ES} \xrightarrow{k_3} \mathrm{E} + \mathrm{P}$$

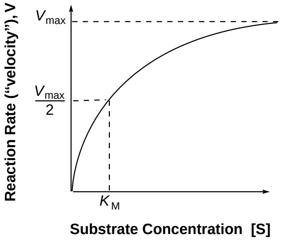

FIGURE 6: Michaelis-Menten model of enzyme kinetics. Adapted from Stryer (1981, p. 111).

$$\frac{d[ES]}{dt} = k_1[E][S] - (k_2 + k_3)[ES]$$

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$$V = V_{max} \times \frac{[S]}{[S]+K_M}$$

Denning (1993)

Enzimas

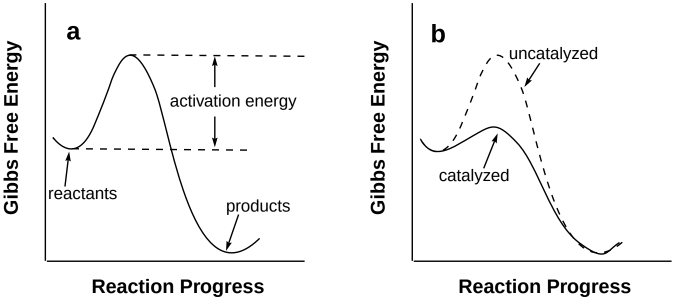


FIGURE 4: Effect of a catalyst on a chemical reaction. **a**) The overall reaction results in a reduction of the Gibbs free energy, but some energy must be supplied to start the reaction. **b**) This activation energy is reduced by introducing a catalyst, although the overall change in the free energy of the system is the same in both cases. Modified from Stryer (1981, p107).

Denning (1993)

Efeito da temperatura

- Q$_{10}$

$$k = k_{25} \times Q_{10}^{(T_k - 298{,}15)/10}$$

- Arrhenius

$$k = k_{25} \times \exp\left(\frac{E_a \times (T_k - 298{,}15)}{298{,}15 \times R \times T_k}\right)$$

$$k = k_{opt} \times \frac{H_d \times \exp\left(\frac{H_a \times (T_k - T_{opt})}{T_k \times R \times T_{opt}}\right)}{H_d - H_a \times \left(1 - \exp\left(\frac{H_d \times (T_k - T_{opt})}{T_k \times R \times T_{opt}}\right)\right)}$$

- Collatz et al. (1991)
- Bernacchi et al. (2001)
- Medlyn et al. (2002)

Fase clara

Cadeia de transporte de elétrons

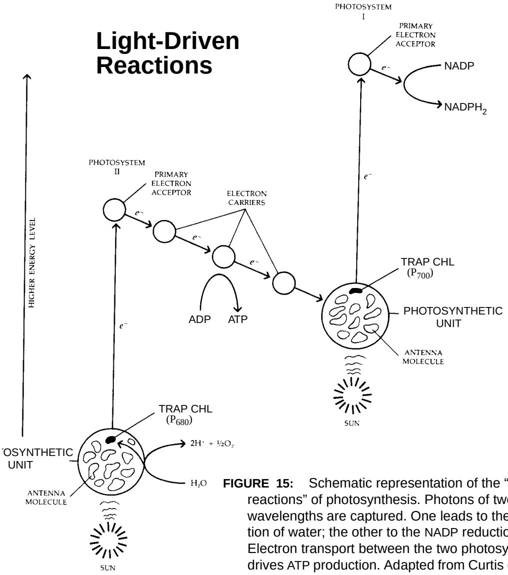
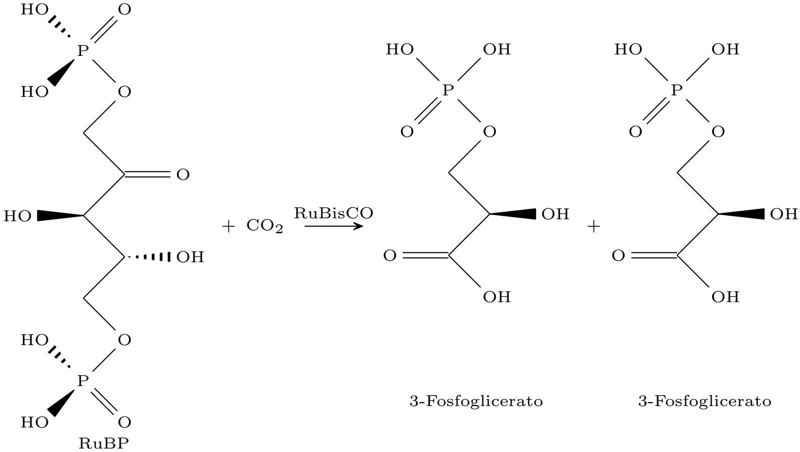


FIGURE 15: Schematic representation of the "light reactions" of photosynthesis. Photons of two wavelengths are captured. One leads to the oxidation of water; the other to the NADP reduction. Electron transport between the two photosystems drives ATP production. Adapted from Curtis (1979).

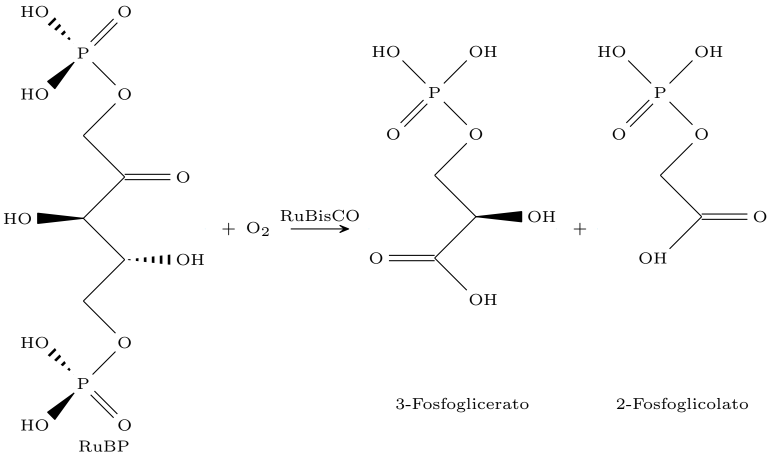
Denning (1993)

Fase escura

RuBP e RuBisCO



RuBP e RuBisCO – Fotorrespiração



Ciclo de Calvin-Benson

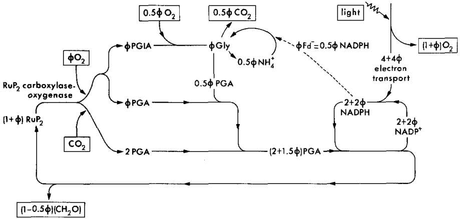


Fig. 1. Simplified photosynthetic carbon reduction (PCR) and photorespiratory carbon oxidation (PCO) cycles, with cycle for regeneration of NADPH linked to light driven electron transport. For each carboxylation, ϕ oxygenations occur. Gly denotes glycine, Fd^- denotes reduced ferredoxin (assumed equivalent to 1/2 NADPH), PGA denotes 3-phosphoglycerate, PGlA phosphoglycolate. At the compensation point $\phi = 2$

$$\phi = \frac{V_o}{V_c} = \frac{V_{o_{max}}}{V_{c_{max}}} \times \frac{O/K_o}{C/K_c}$$

Farquhar, Caemmerer e Berry (1980)

Modelos

- Farquhar, Caemmerer e Berry (1980)
- Collatz et al. (1991)
  - R_d
  - V_{max}
- Bernacchi et al. (2001)
  - K_o
  - K_c
- Medlyn et al. (2002)
  - J_{max}
- Bonan (2008)

Modelos

$A_n = \min\{w_c, w_j, w_s\} - R_d$

- w_c = taxa de fotossíntese limitada pela RuBisCO
- w_j = taxa de fotossíntese limitada pela cadeia de transporte de elétrons
- w_s = taxa de fotossíntese limitada pela síntese do produto final (sacarose)
- R_d = carbono perdido pela respiração

Limite pela RuBisCO

$$w_c = V_{c_{max}} \times \frac{C}{C + K_c \times (1 + O/K_o)}$$

Farquhar, Caemmerer e Berry (1980)

Limite pela RuBisCO

$$w_c = V_{c_{max}} \times \frac{C}{C + K_c \times (1 + O/K_o)}$$

- K_o = Constante de Michaelis para oxigenação
- K_c = Constante de Michaelis para carboxilação

Farquhar, Caemmerer e Berry (1980)

Limite pela cadeia de transporte de elétrons

$$w_j = \frac{J}{4} \times \frac{C - \Gamma*}{C + 2\Gamma*}$$

Medlyn et al. (2002)

Limite pela cadeia de transporte de elétrons

$$w_j = \frac{J}{4} \times \frac{C - \Gamma*}{C + 2\Gamma*}$$

$$\theta J^2 - (\alpha \times APAR + J_{max})J + \alpha \times APAR \times J_{max} = 0$$

Medlyn et al. (2002)

Limite pela cadeia de transporte de elétrons

$$w_j = \frac{J}{4} \times \frac{C - \Gamma*}{C + 2\Gamma*}$$

$$\theta J^2 - (\alpha \times APAR + J_{max})J + \alpha \times APAR \times J_{max} = 0$$

- $\Gamma* =$ Ponto de Compensação de CO_2 (sem R_d)

Medlyn et al. (2002)

Limite pelo produto final

$$w_s = \frac{V_{max}}{2}$$

Collatz et al. (1991)

Ponto de compensação de CO_2

Pressão parcial de CO_2 em que a assimilação líquida é nula

- Sem R_d

$$\Gamma * = \frac{K_c \times V_{o_{max}} \times O}{2 \times K_o \times V_{c_{max}}}$$

- Com R_d

$$\Gamma = \frac{\Gamma * + K_c \times (1 + O/K_o) \times R_d/V_{c_{max}}}{1 - R_d/V_{c_{max}}}$$

Farquhar, Caemmerer e Berry (1980)

Correções para $V_{c_{max}}$ e R_d

$$V_{c_{max}} = \frac{V^o_{c_{max}}}{1 + exp\left[\frac{-a+b\times(T_k)}{R\times T_k}\right]}$$

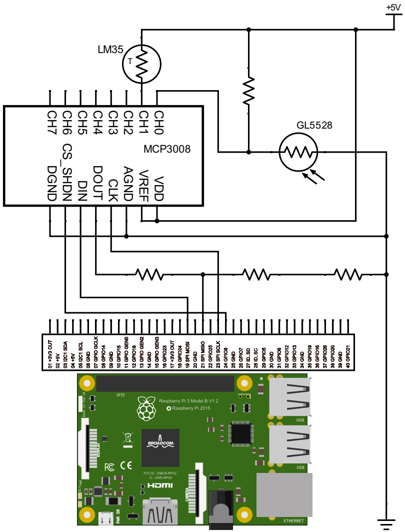
$$R_d = \frac{R^o_d}{1 + exp[1,3 \times (T_k - 328,15)]}$$

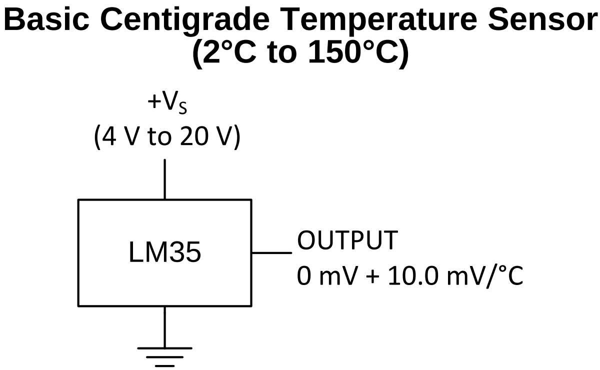
Collatz et al. (1991)

Circuito

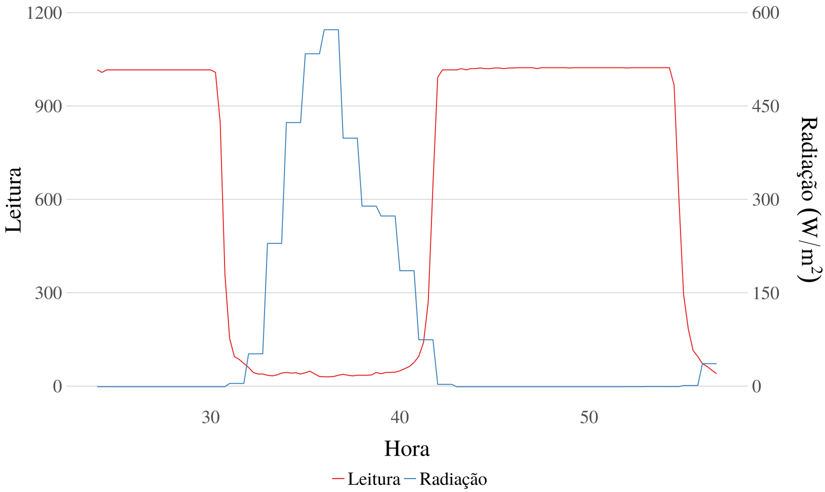
- Raspberry Pi
- Leitura de temperatura – LM35
- Leitura de luminosidade – GL5528
- MCP3008

Circuito


+5V
LM35
T
GL5528
MCP3008
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
VDD
VREF
AGND
CLK
DOUT
DIN
CS_SHDN
DGND

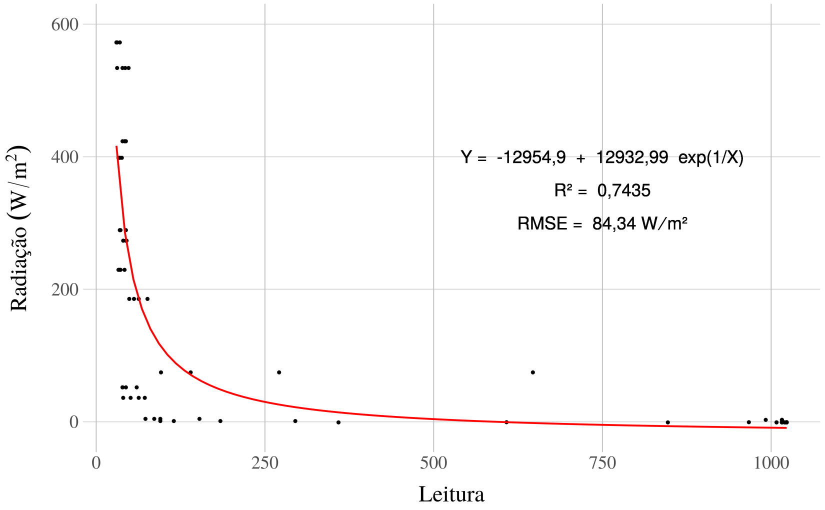

Basic Centigrade Temperature Sensor
(2°C to 150°C)
+V_S
(4 V to 20 V)
LM35
OUTPUT
0 mV + 10.0 mV/°C

GL5528



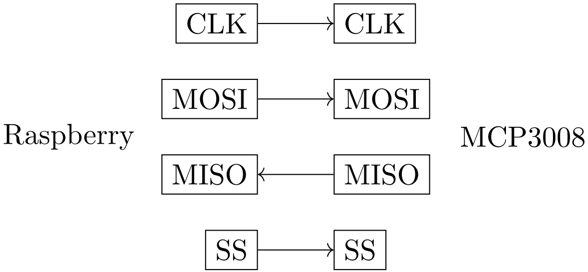
1200
900
600
300
0
Leitura
600
450
300
150
0
Radiação (W/m2)
30
40
50
Hora
Leitura
Radiação

GL5528



Y = -12954,9 + 12932,99 exp(1/X)
R² = 0,7435
RMSE = 84,34 W/m²
Radiação (W/m²)
Leitura
0
200
400
600
0
250
500
750
1000

Protocolo SPI para comunicação serial:



MCP3008

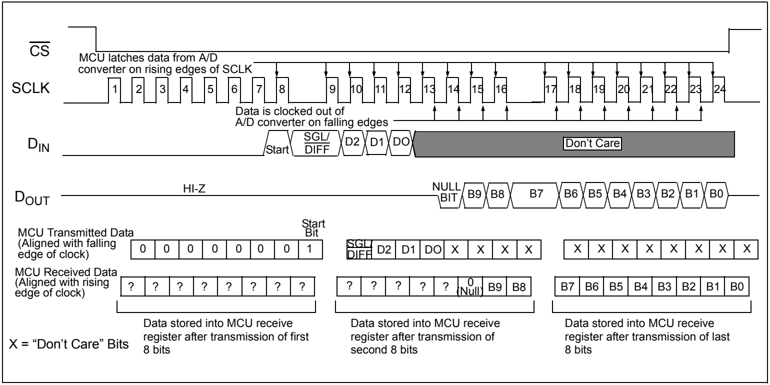


FIGURE 6-1: *SPI Communication with the MCP3004/3008 using 8-bit segments (Mode 0,0: SCLK idles low).*

Código

- Leitura dos dados
- Modelo
- Gráfico

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MEDLYN, B. et al. Temperature response of parameters of a biochemically based model of photosynthesis. ii. a review of experimental data. *Plant, Cell & Environment*, Wiley Online Library, v. 25, n. 9, p. 1167–1179, 2002.