Relações entre a Fotossíntese e a Atmosfera

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por quê as plantas são verdes?

Não! as algas que são.

A amazônia é o pulmão do mundo.
Por quê as plantas são verdes?

Mecanismo da Fotofosforilação Oxidativa:

[Diagrama de uma célula cloroplastica com marcas para Granum, Tlacóides e Estroma]

clorofila B
clorofila B
2 e-

clorofila
B
$\text{H}_2\text{O} \rightarrow \frac{1}{2} \text{O}_2 + 2 \text{H}^+$

chlorofila B

Feofitina

Plastocinona

Complexo Citocromo b f

Plastocianina

chlorofila A

$\text{ATP}$

$\text{ATP}$

$\text{ATP}$

Proteína sulforosa

Óxido de ferro

NADPH
Porque a planta é verde?

Tipos diferentes de Espectros Moleculares:

- Espectro Vibracional/Rotacional
- Espectro Eletrônico de Banda
- Radiação Ionizante

Fontes:
- Robinson Rolim Resseti [2]
- Abud Science [3]
- NASA [4]
- Radiação Médica [5]
Espectro Vibracional/Rotacional

bending

symmetric stretching

asymmetric stretching

vibrational motion

rotational motion

Espectro Eletrônico de Banda

Photon

Ground State

Excited State

Radiação Ionizante

Electron

Energia

$10^5$ Hz

$10^{13}$ Hz

$10^{14} - 10^{16}$ Hz

$10^{17}$ Hz

$10^{19}$ Hz

luz visível

percentual de absorção

comprimento de onda (nm)

violeta | azul | verde | amarelo | laranja | vermelho

clorofila a

clorofila b
Espectro de emissão solar:

Fonte: Eduardo Landufo [6]
Espectro de emissão solar:

Mas então por que não uma clorofila preta?

Fonte: Eduardo Landufo [6]
Mas então por que não uma clorofila preta?

KIANG, SIEFERT, GOVINDJEE, BLANKENSHIP:

“A banda de Chappuis para O3 (500-700nm) altera o pico da densidade de fluxo de fótons do Sol do seu comprimento usual de 600nm (detectados no topo da atmosfera) para 685nm na superfície terrestre, o que pode explicar porque a clorofila prefere o vermelho ao verde.

Dessa forma, parece que o pico de absorção na janela do vermelho foi uma adaptação para aproveitar a janela de transmitância do Sol com a maior abundância de fótons, janela cujos limites são definidos tanto pelo espectro solar quanto pela própria presença de O2 e O3. Note que se considerarmos na superfície terresre o espectro em termos de fluxo de energia, o pico acontece em 480-490nm, mas como para a fotossíntese conta-se fótons, e não energia, o pico acaba sendo deslocado”

IRTADIANCE
(photons/m²/s/µm)
Top of atmosphere
Earth surface
Hawaii meas.

PIGMENT
ABSORBANCE
and
Chl a FLUORESCENCE
(arbitrary units)

O₂
H₂O
CO₂

6E+21
5E+21
4E+21
3E+21
2E+21
1E+21
0

200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400

wavelength (nm)

O₃

Mas isso é válido nas condições da atmosfera primitiva?
The earliest version of the pathway almost certainly was anaerobic, both not requiring and not tolerating the presence of O2.

Photosynthetic phyla include the cyanobacteria, proteobacteria (purple bacteria), green sulfur bacteria (GSB), firmicutes (heliobacteria), filamentous anoxygenic phototrophs (also often called the green nonsulfur bacteria), and acidobacteria.

Fonte: Early Evolution of Photosynthesis [8]
influência da atmosfera na fotossíntese

X

influência da fotossíntese na atmosfera
influência da atmosfera no processo de fotossíntese
<table>
<thead>
<tr>
<th>Driver</th>
<th>Hypothesis</th>
<th>Description of mechanism</th>
<th>Level of driver</th>
<th>Impact of driver</th>
<th>Scale of change</th>
<th>Type of change</th>
<th>Extent of change</th>
<th>Absolute annual change $^d$</th>
<th>Theoretical consistency of effects? $^e$</th>
<th>Mechanism experimentally demonstrated?</th>
<th>Key prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>Air temperature</td>
<td>Long-term temperature increases affect photosynthesis, increasing/decreasing growth rates</td>
<td>Physical</td>
<td>Growth</td>
<td>Regional</td>
<td>Point</td>
<td>Global</td>
<td>+0.024°C</td>
<td>No</td>
<td>Yes</td>
<td>Growth rate changes correlate with local temperature trends</td>
</tr>
<tr>
<td>Air temperature</td>
<td>Respiration costs</td>
<td>Long-term temperature increases increase respiration rates, decreasing growth rates</td>
<td>Physical</td>
<td>Growth</td>
<td>Regional</td>
<td>Point</td>
<td>Global</td>
<td>+0.024°C</td>
<td>Yes</td>
<td>Yes</td>
<td>Growth rate changes correlate with increases of minimum temperatures</td>
</tr>
<tr>
<td>Air temperature</td>
<td>Soil warming</td>
<td>Long-term temperature increases soil nutrient availability, increasing or decreasing growth rates</td>
<td>Physical</td>
<td>Growth</td>
<td>Regional</td>
<td>Point</td>
<td>Global</td>
<td>+0.024°C</td>
<td>No</td>
<td>Partially $^{i}$</td>
<td>Growth rate changes correlate with local temperature trends with highest relative increases on</td>
</tr>
<tr>
<td>Solar radiation</td>
<td>Global dimming</td>
<td>Long-term decreases in insolation affects photosynthesis increasing/decreasing growth rates</td>
<td>Physical</td>
<td>Growth</td>
<td>Regional</td>
<td>Point</td>
<td>Regional or near-global</td>
<td>$-0.30 \text{ W m}^{-2}$</td>
<td>No</td>
<td>Partially $^{i}$</td>
<td>Growth rate changes correlate with local insolation trends</td>
</tr>
<tr>
<td>Solar radiation</td>
<td>Changing energy budget</td>
<td>Recent increases in solar radiation due to decreased cloudiness increases</td>
<td>Physical</td>
<td>Growth</td>
<td>Regional</td>
<td>Point</td>
<td>Regional</td>
<td>$+0.13 \text{ W m}^{-2}$</td>
<td>Yes</td>
<td>Yes</td>
<td>Growth rate changes correlate with local insolation trends</td>
</tr>
<tr>
<td>CO$_2$ light use efficiency</td>
<td></td>
<td>Long-term atmospheric CO$_2$ increases increase photosynthesis, increasing growth rates</td>
<td>Chemical</td>
<td>Growth</td>
<td>Global</td>
<td>Point</td>
<td>Global</td>
<td>$+1.53 \text{ ppm}$</td>
<td>Yes</td>
<td>Yes</td>
<td>Growth rate increases across most forests with greatest absolute increase in nutrient-rich aseasonal forests</td>
</tr>
</tbody>
</table>

*Fonte: Tropical forests and global atmospheric change, Malhi and Phillips [10]*
Temperatura do ar/solo

A temperatura estimula as reações enzimáticas de todos os processos.

em particular, para florestas tropicais:

- taxas de crescimento correlacionadas com menores temperaturas  
  respiration domina

- taxas de crescimento correlacionadas com maiores temperaturas  
  fotossíntese domina

- taxas de crescimento correlacionadas com mudanças na temperatura, mas efeitos são desproporcionalmente maiores e positivos em florestas de solo pobre em nutrientes

aquecimento do solo

Fonte: Tropical forests and global atmospheric change, Malhi and Phillips [10]
Concentração de CO$_2$
Incidência solar

White light is scattered in all directions

Some light penetrates to cloud base

White light is scattered in all directions

Atriplex triangularis
(sun plant)

Asarum caudatum
(shade plant)

Photosynthetic CO₂ assimilation (µmol m⁻² s⁻¹)

Photosynthetically active radiation
Irradiance (µmol m⁻² s⁻¹)

Fonte: NASA [14]
Incidência solar: aerossol

influência da fotossíntese na atmosfera
Influência da fotossíntese na atmosfera

Afinal, a amazônia é de fato “o pulmão do mundo”?

Emmanuel Macron
@EmmanuelMacron

Our house is burning. Literally. The Amazon rain forest - the lungs which produces 20% of our planet's oxygen - is on fire. It is an international crisis. Members of the G7 Summit, let’s discuss this emergency first order in two days! #ActForTheAmazon
Influência da fotossíntese na atmosfera

Afinal, a amazônia é de fato “o pulmão do mundo”?

- A Amazônia é o pulmão do mundo
algas marinhas:

Eu sou uma piada para você?

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89.5K people are talking about this
Influência da fotossíntese na atmosfera

Afinal, a amazônia é de fato “o pulmão do mundo”?

- Clímax ecológico
- Atmosférico no período pré-industrial
- Atmosférico no período pós-industrial

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Slow in, Rapid out—Carbon Flux Studies and Kyoto Targets

Christian Körner

Terrestrial plants and soil humus store about three times as much carbon as is contained in the carbon dioxide (CO₂) in Earth’s atmosphere. Thus, a loss of this storage capacity is highly dynamic. Terrestrial plants recycle the equivalent of the atmosphere’s carbon content about every 10 years. Forests play a particularly important role because almost 90% of all terrestrial humus is stored in trees, and 50% of the terrestrial organic carbon is stored in forests (1). A net release or uptake (sequestration) of carbon by forests could have a large impact on the atmosphere’s CO₂ concentration (2).

However, it is no surprise that the carbon balance of the world’s forests plays a key role in the ongoing debate about climate change mitigation (2-4). From this point of view, studies of carbon flux in forests are highly relevant. The reason is not only that carbon flux in forests is a major factor in the atmosphere’s CO₂ concentration (2). The reason is also that forests are such important sinks for carbon, and that rates of atmospheric carbon uptake by forests are large (5).

Modern technology permits the carbon balance of forests to be determined with unprecedented precision using CO₂ flux measurements (2). With a few sophisticated sensors it is possible to monitor the forest’s net carbon exchange at a unit of land area (NIE) can be recorded continuously (3). NIE is a negative, the carbon pool of the ecosystem is expanding and carbon is sequestered. NIE is positive, the system is a net carbon emitter.

Three technical tools help to determine the carbon budget of a given forest at the process level (fluxes in versus fluxes out). However, such measurements have limited potential to contribute to a quantification of a region’s, a nation’s, or a subcontinent’s carbon budget. These limitations deserve wider acknowledgment, given the hope tied to such studies for carbon accounting within the Kyoto protocol.

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Fonte: IPCC AR5 Climate Change 2013 [12].
Período pós-industrial

Fonte: IPCC AR5 Climate Change 2013 [12]
By contrast, since the beginning of the Industrial Era, fossil fuel extraction from geological reservoirs, and their combustion, has resulted in the transfer of significant amount of fossil carbon from the slow domain into the fast domain, thus causing an unprecedented, major human-induced perturbation in the carbon cycle.

Fonte: IPCC AR5 Climate Change 2013 [12]
By contrast, since the beginning of the Industrial Era, fossil fuel extraction from geological reservoirs, and their combustion, has resulted in the transfer of significant amount of fossil carbon from the slow domain into the fast domain, thus causing an unprecedented, major human-induced perturbation in the carbon cycle.
Compared to the atmospheric oxygen content of about 21% this decrease is very small; however, it provides independent evidence that the rise in CO2 must be due to an oxidation process, that is, fossil fuel combustion and/or organic carbon oxidation, and is not caused by, for example, volcanic emissions or by outgassing of dissolved CO2 from a warming ocean.
Albedo_{Floresta} < Albedo_{Área desmatada}

Albedo_{Floresta} > Albedo_{Área queimada} (temporário)

Albedo_{Floresta} > Albedo_{Área urbana} (ilha de
vegetation and the surface radiation processes. On this basis, AR4 gave a best estimate of RF relative to 1750 due to land use related surface albedo at $-0.2 \pm 0.2 \text{ W m}^{-2}$ with a level of scientific understanding at medium-low.
Fontes e Referências Bibliográficas

[1] https://blogdoenem.com.br/biologia-enem-velocidade-fotossintese/


