The Same Act of Nine-Folding the Light Differs Fivefold in Effect, Depending on Where One Already Stands

— With a rectangular hyperbola and a half-saturating irradiance of **200**, the rate at exactly half-saturation is **0.500000** and at nine times that it is **0.900000**, a factor of only **1.800000** — the separator is whether what is short is the light arriving or the machinery receiving it — [Paper 737]

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— From thinking to syncing. —

Abstract

Photosynthesis stops speeding up as the light rises. That it saturates is known. What is counted here is how far the effect of one act varies.The single act of nine-folding the light is compared at four levels of brightness.No new theorem or law is claimed. First, at half-saturation the rate is exactly half——0.500000, which is the definition of the form (Section 2). **Second, in the bright, nine-folding barely acts——from one to nine times half-saturation the rate reaches 0.900000, a factor of only 1.800000** (Section 2). **Third, and this is the core. The same nine-folding gives 8.928642 in the dark——from 0.001 to 0.009 of half-saturation, a fivefold difference in effect** (Section 3). **Fourth, the range between joins smoothly——8.339450 from 0.01 to 0.09 and 5.210526 from 0.1 to 0.9** (Section 3). **Fifth, so dividing the same light raises the total——by 1.500000 at an irradiance of 400 and 1.818182 at 1800: the stronger the light, the more is gained** (Section 3). **Sixth, the separator is whether what is short is the light arriving or the machinery receiving it——in the second case one adds receivers rather than light** (Section 4).
Keywords: photosynthesis, light saturation, rectangular hyperbola, half-saturating irradiance, shift of the limiting factor, arriving light or receiver.

Scope of this paper (scope note): **No new theorem or law is claimed——that the light response of photosynthesis saturates, that it is approximated by a rectangular hyperbola, and the use of a half-saturating irradiance are all standard (Blackman 1905, Larcher 2003).The form is assumed——the rectangular hyperbola and a half-saturating irradiance of 200 are representative; no value for a real plant is claimed. Units are left open and only ratios are read.Photoinhibition is not treated——the fall in rate under excessive light is not treated; the account stops at saturation.Other limitations are not treated——carbon dioxide, temperature and water limitation are not treated.Respiration is not subtracted——the difference between net and gross photosynthesis is not treated.** ⚠️ **A simplification on the divided side——overlapping leaves receive less light below, yet here the two leaves are each counted as receiving the same irradiance. To that extent the gain from dividing is an upper bound.Relation to earlier papers**: **Paper 417 showed that the ceiling on food-chain length is not a fact about animals——there the loss in passing energy up a level was the subject, treating the middle of the chain. Here we stand at the very entrance of the same chain, where light goes unused though it is abundant. The loss between levels, and the ceiling at the entrance.**What is added is **tabulating one nine-folding at four levels of brightness**, **showing its effect to range from 1.800000 to 8.928642**, **deriving the total when the light is divided**, **showing the gain to grow with the light**, and **placing the separator on arriving light against receiving machinery**.

1. Notation and the Question

Setting: **the rate of photosynthesis rises with light and then levels off. Written as a rectangular hyperbola it reads as follows.**

$$P(I) = P_{\max}\frac{I}{I + I_k}, \qquad P(I_k) = \tfrac{1}{2}P_{\max}$$

I_k is the half-saturating irradiance. Take $I_k = 200$ and $P_{\max} = 1$ as representative, leave the units open and read only ratios.

Question: **does the act of “adding light” have one effect?**

2. In the Bright, Nine-Folding Barely Acts

Computation 2.1: **the rate was derived for each irradiance.**

irradiance	against half-saturation	rate
50	0.250000	0.200000
100	0.500000	0.333333
200	1.000000	0.500000
400	2.000000	0.666667
800	4.000000	0.800000
1800	9.000000	0.900000

Observation 2.2

nine-folding from half-saturation gives only 1.800000.From 0.500000 to 0.900000——eight extra measures of light are poured in and the rate does not double.

Observation 2.3

the rate cannot exceed $P_{\max}$.At an irradiance of 10^{6} it is 0.999800——the ceiling lies on the receiving side and not in the quantity of light arriving.

3. One Nine-Folding, Fivefold Difference

Computation 3.1: the single act of nine-folding the light was compared at four levels of brightness.

interval nine-folded (half-saturation as 1)	factor on the rate
0.001 to 0.009	8.928642
0.010 to 0.090	8.339450
0.100 to 0.900	5.210526
1.000 to 9.000	1.800000

Observation 3.2

this is the core: one act varies in effect from 1.800000 to 8.928642.Nothing about the act has changed——what changed is only where one already stands.

Observation 3.3

dark enough, and it is nearly proportional.From 0.001 to 0.009 it gives 8.928642, approaching nine——in the dark the light is limiting; in the bright the receiver is.

Computation 3.4: the total was derived for one leaf receiving all the light and for two leaves receiving half each.

irradiance	one leaf	two at half each	ratio
400	0.666667	1.000000	1.500000
1800	0.900000	1.636364	1.818182

Observation 3.5

dividing raises the total.By 1.500000 at an irradiance of 400 and 1.818182 at 1800——more is taken by spreading over two unsaturated leaves than by pouring into one saturated leaf.

Observation 3.6

the stronger the light, the more dividing gains.From 1.500000 to 1.818182——under strong light, adding receivers is what acts.

Observation 3.7

this computation is simplified.Overlapping leaves receive less light below, yet the two leaves were each counted as receiving the same irradiance——so the gain shown is an upper bound and is not a claim about real canopy design.

4. The Separator

> **Observation 4.1**
>
> **the separator is whether what is short is the light arriving or the machinery receiving it.In the first case one adds light; in the second one adds receivers——the one phrase “not enough light” names two different remedies.**

> **Observation 4.2**
>
> **beside Paper 417.Paper 417 showed that the ceiling on food-chain length is not a fact about animals——there the loss in passing up a level was the subject. Here we stand at the entrance of the same chain, where light goes unused though abundant. The loss between levels, and the ceiling at the entrance.**

> **Observation 4.3**
>
> **what is not said.Photoinhibition, carbon dioxide, temperature and respiration are not treated, and shading between leaves is not included——what is shown is that the effect of one act depends on where one stands.**

5. Roll Call and Closing

1. **0.500000 at half-saturation** (Computation 2.1): **the definition.**
2. **0.900000 at nine times** (Computation 2.1): **it levels off.**
3. **a factor of 1.800000** (Observation 2.2): **it does not double.**
4. **8.928642 in the dark** (Computation 3.1): **the core.**
5. **8.339450 from 0.01 to 0.09** (Computation 3.1): **in between.**
6. **5.210526 from 0.1 to 0.9** (Computation 3.1): **joining smoothly.**
7. **0.999800 at 10^{6}** (Observation 2.3): **the ceiling is the receiver.**
8. **1.500000 with two leaves** (Computation 3.4): **at an irradiance of 400.**
9. **1.818182 with two leaves** (Computation 3.4): **at 1800; stronger gains more.**
10. **arriving light or receiver** (Observation 4.1): **the separator; Paper 417.**

Closing: **The same act of nine-folding the light differs fivefold in effect, depending on where one already stands.With a rectangular hyperbola and a half-saturating irradiance of 200, the rate at exactly half-saturation is 0.500000 and at nine times that it is 0.900000, a factor of only 1.800000——eight extra measures of light are poured in and the rate does not double.Yet the same nine-folding performed in the dark gives 8.928642 from 0.001 to 0.009 of half-saturation, 8.339450 from 0.01 to 0.09 and 5.210526 from 0.1 to 0.9——nothing about the act has changed and the effect differs fivefold; what changed is only where one already stands, the light being limiting in the dark and the receiver in the bright.The rate cannot exceed $P_{\max}$, reaching only 0.999800 at an irradiance of 10^6——the ceiling lies on the receiving side and not in the quantity of light arriving.So dividing the same light between two leaves raises the total, by 1.500000 at an irradiance of 400 and 1.818182 at 1800——the stronger the light, the more dividing gains, and under strong light adding receivers is what acts.Overlapping leaves would receive less light below, yet the two were each counted as receiving the same irradiance, so the gain shown is an upper bound.The separator is whether what is short is the light arriving or the machinery receiving it——the one phrase "not enough light" names two different remedies.Placed among the earlier papers——Paper 417 treated the loss between levels; here it is the ceiling at the entrance of the same chain.To be honest——photoinhibition, carbon dioxide, temperature and respiration are not treated, and shading between leaves is not included.**

References

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