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Editorial

Symbols, Système International (SI) Units, Abbreviations, Conversion Factors and Special Instructions to be Used in Photosynthesis Research

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Abstract. I have been thinking for a long time of publishing a list of symbols, SI units, abbreviations and conversion factors for the convenience of the authors. Authors planning to prepare their manuscripts for publication in *Photosynthesis Research* should consult the following lists to conform to the rules of the style to be used in this Journal. Please note that no periods should be used with most acronyms (*e.g.*, DNA, USA, UK, etc.) Please send queries and suggestions regarding these rules to one of the chief or associate editors. We hope that the following list will be helpful to our authors.

A. Symbols

Authors may use three-letter symbols for amino acids without definition but the one-letter symbols should be defined in their abbreviation list. Other symbols need not be defined.

Symbols for Amino Acids. Three-letter symbols should be used only in representing short polymers or short sequences and in tables and figures. However, single-letter symbols are to be used when the sequence of entire protein or a large polypeptide is to be described.

Amino Acid	Three-letter symbol	One-letter symbol
Alanine	Ala	A
Arginine	Arg	R
Asparagine	Asn	N
Aspartic Acid	Asp	D
Cysteine	Cys	C
Glutamine	Gln	Q
Glutamic acid	Glu	E
Glycine	Gly	G
Histidine	His	H
Hydroxylysine	Hyl	–
Hydroxyproline	Hyp	–

Amino Acid	Three-letter symbol	One-letter symbol
Isoleucine	Ile	I
Leucine	Leu	L
Lysine	Lys	K
Methionine	Met	M
Phenylalanine	Phe	F
Proline	Pro	P
Serine	Ser	S
Threonine	Thr	T
Tryptophan	Trp	W
Tyrosine	Tyr	O
Valine	Val	V

Symbols for Sugars			
Arabinose	Ara	Fructose	Fru
Galactose	Gal	Fucose	Fuc
Glucose	Glc	Ribose	Rib
Mannose	Man	Sucrose	Suc
		Xylose	Xyl

Phosphosylated derivatives may be depicted as phosphate derivatives of the parent compounds with P- or -P representing phosphate, as in ribulose -1,5-bisP (RuBP).

Other symbols	
on this side of (isomerism)	cis
across or over (isomerism)	trans
ortho	o
meta	m
para	p
normal	n
secondary	sec
tertiary	tert

B. Names and symbols of SI units*

Quantity	Unit	Symbol
acceleration	meter per second squared	$m\,s^{-2}$
activity (of a radioactive source)	1 per second	s^{-1}
angular acceleration	radian per second squared	$rad\,s^{-2}$
angular velocity	radian per second	$rad\,s^{-2}$
area	square meter (m)	m^2
density	kilogram per cubic meter	$kg\,m^3$
dynamic viscosity	newton-second per sq meter	$N\,s\,m^{-2}$
electric capacitance	farad (ampere. second per volt)	$F\ (A\,s\,V^{-1})$
electric charge	coulomb (ampere. second)	C (As)
electric current	ampere	A
electric field strength	volt per meter	$V\,m^{-1}$
electric resistance	ohm (volt/ampere)	$\Omega\ (V\,A^{-1})$
entropy	joule per kelvin	$J\,K^{-1}$
fluence	kilojoule per sq meter	$KJ\,m^{-2}$
fluence rate	watt per sq meter	$W\,m^{-2}$
force	newton (kilogram. meter per second squared)	$N\ (Kgm\,s^{-2})$
frequency	hertz (1 per second)	$Hz\ (s^{-1})$
inductance	henry (volt. second per ampere)	$H\ (Vs\,A^{-1})$
kinematic viscosity	sq meter per second	$m^2\,s^{-1}$
land area	hectare ($=10^4\,m^2$)	ha
length	meter	m
magnetic field strength	ampere per meter	$A\,m^{-1}$
magnetic flux	weber (volt. second)	Wb (Vs)
magnetic flux density	tesla (weber. $meter^{-2}$)	$T\ (Wb\,m^{-2})$
magnetomotive force	ampere	A
mass	kilogram	kg
power	watt (joule per second)	$W\ (J\,s^{-1})$
plane angle	radian	rad
pressure	pascal (newton per sq meter)	$Pa\ (N\,m^{-2})$
radiant intensity	watt per steradian	$W\,sr^{-1}$
solid angle	steradian	sr
specific heat	joule per kilogram kelvin	$J\,Kg^{-1}\,K^{-1}$
temperature	degrees kelvin or degrees celsius	K or °C
thermal conductivity	watt per meter kelvin	$W\,m^{-1}\,K^{-1}$
time	second	s
velocity	meter per second	$m\,s^{-1}$
voltage, potential difference, electromotive force	volt (watt per ampere)	$V(W\,A^{-1})$
volume	cubic meter (m)	m^3
wave number	1 per meter	m^{-1}
work energy, quantity of heat	joule (newton. meter)	J(Nm)

* Use of division sign is discouraged to avoid ambiguity; it is better to use negative indices. Submultiples are not allowed under SI (*e.g.*, use $mol\,m^{-2}\,s^{-1}$, not $mol\,dm^{-2}\,h^{-1}$)

C. Abbreviations

Authors may use, without definition, the abbreviations in this list. Define all other abbreviations in the paper. Spell out words in the title and the abstract (except common symbols such as ADP, ATP, RNA, DNA), and words and numerals that begin a sentence.

C.1. Units

Units of measurement	Prefixes to the names of units
atto (10^{-18})	a
femto (10^{-15})	f
pico (10^{-12})	p
nano (10^{-9})	n
micro (10^{-6})	μ
milli (10^{-3})	m
centi (10^{-2})	c
deci (10^{1})	d
kilo (10^{3})	k
mega (10^{6})	M
nano (10^{-9})	n
pico (10^{-12})	p
tera (10^{12})	T

Units of concentration

micromolar (micromol/liter)	μmol (in preference to 10^{-6} M)
millimolar (millimol/liter)	m mol (in preference to 10^{-3} M)
molar (mol/liter)	mol (K mol m^{-3})

Units of area and volume

liter	l (special name for dm^3) or spell out if used without reference to another unit of measure
microliter	do not use μl (λ); use mm^3
milliliter	do not use ml; use cm^3

Units of mass

gram	g
microgram	μg (not γ)
milligram	mg

Units of time

day	d
hour	h
minute	min
second	s

Units of length

centimeter	cm
meter	m
micrometer	μm (not μ)
millimeter	mm
nanometer	nm (not mμ)

C.2 Other abbreviations

Name	*Symbol*
A	
absorbance (absorbance at 700 nm)	A(A700)
adenosine 5 -mono-, di, triphosphate	AMP, ADP, ATP
ambient CO_2 concentration	Ca (μmol^{-1} or Pa)
atmosphere(s)	use Pa (for Pascal)
B	
bacteriochlorophyll	BChl
bacteriopheophytin	BPheo
becquerel	use Bq; 1 curie = 3.7×10^{10} Bq
N,N′-bis(2-hydroxyethyl)glycine	Bicine
p-bis-2-(5-phenyloxazolyl)benzene	POPOP
boundary layer conductance	gb ($mmol\,m^{-2}\,s^{-1}$)
bovine serum albumin	BSA
C	
carbon dioxide uptake rate	**A** ($\mu mol\,m^{-2}\,s^{-1}$)
chlorophyll	Chl
Chlorophyllide	Chlide
circa (approximately)	ca.
Crassulacean acid metabolism	CAM
cyclic adenosine 3′:5′-monophosphate	cAMP
cytochrome	Cyt
D	
dalton	D
deoxyribonuclease	DNase
deoxyribonucleic acid	DNA
complementary DNA	cDNA
chloroplast DNA	ctDNA
nuclear DNA	nDNA
deuterium	^2H
diameter	dia
3-(3,4-dichlorophenyl)-1,1-dimethylurea, diuron	DCMU
diethylaminoethyl	DEAE
dimethyl sulfoxide	DMSO
2,5-diphenyloxazole	PPO
dithioerythritol	DTE
dithiothreitol	DTT
E	
electron microscopy	EM
electron paramagnetic resonance	EPR
endoplasmic reticulum	ER

Name	*Symbol*
equation	Eq.
ethylenediaminetetraacetate	EDTA
ethyleneglycol-bis (β-aminoethyl ether)-N,N′-tetraacetic acid	EGTA
equilibrium constant	K
F	
ferredoxin	Fd
Figure	Fig. (parentheses only)
G	
gas chromatography-mass spectrometry	GC-MS
gas-liquid chromatography	GLC
gauss	G
gravity (acceleration due to) (5,000 times gravity)	**g** (5,000 g)
Gyromagnetic ratio in EPR	**g**
H	
hectare	ha
N-2-hydroxyethylpiperazine-N-2-ethanesulfonic acid	Hepes
high performance liquid chromatography	HPLC
hydrogen ion concentration, negative log of	pH
I	
infrared	IR
inner diameter	i.d.
J	
joule	J
K	
kilodalton	kDa
L	
leaf internal CO_2 concentration	Ci (μmol mol^{-1}or Pa)
logarithm (common, base 10)	log
logarithm (natural)	ln
M	
mass spectrometry	MS
Michaelis constant	Km
mole (a gram molecule)	mol
molecular weight	mol wt

Name	*Symbol*
2-(N-morpholino) ethanesulfonic acid	Mes
N	
nicotinamide adenine dinucleotide and its reduced form	NAD (or NAD^+), NADH
nicotinamide adenine dinucleotide phosphate and its reduced form	NADP (or $NADP^+$), NADPH
nuclear magnetic resonance	NMR
number	No. (tables and parentheses)
O	
orthophosphate	Pi
osmotic potential (see solute potential)	
outer diameter	o.d.
P	
pascal (unit of pressure)	Pa; 100 kPa = 1 bar
percent	%
pheophytin	Pheo
photosynthetically active radiation	PAR (use $W m^{-2}$)
photosystem I or II	PSI or PSII
1,4-piperazinediethanesulfonic acid	Pipes
polyacrylamide gel electrophoresis	PAGE
polyethylene glycol	PEG
precipitate	ppt (in tables)
probability	P
protochlorophyll	PChl
protochlorophyllide	Pchlide
pyrophosphate	PPi
Q	
quantum flux of photosynthetically active light	Q ($\mu mol\, m^{-2} s^{-1}$)
quantum yield of CO_2 uptake	Φco_2
R	
rate constant	k
relative humidity	RH
revolutions per minute	rpm
ribonuclease	RNase
ribonucleic acid	RNA
messenger RNA	mRNA
nuclear RNA	nRNA
ribosomal RNA	rRNA
transfer RNA	tRNA

Name	*Symbol*
S	
sodium dodecyl sulfate	SDS
solute potential	Ψs (MPa)
species	sp. (when part of binomial)
standard deviation of series	SD
standard error of mean	SE
stomatal conductance	gs (μmol $m^{-2} s^{-1}$)
Svedberg	S
T	
temperature, absolute	T
temperature, melting	Tm
thin layer chromatography	TLC
transpiration rate	E (μmol $m^{-2} s^{-1}$)
trichloroacetic acid	TCA
tris(hydroxymethyl)aminomethane	Tris
N-tris(hydroxymethyl)methyl-2-aminoethanesulfonic acid	Tes
N-tris(hydroxymethyl)methylglycine	Tricine
tritium	^{3}H
turgor potential	Ψ_p (MPa)
U	
ultraviolet	UV
V	
volume(s)	vol (in tables)
volume/volume (concentration)	v/v
W	
water potential	Ψ_p (MPa)
weight	wt (tables)
weight/volume (concentration)	w/v

D. Conversion factors

To convert from	to	multiply by
acre	meter^2	4.046×10^3
acre	hectare	0.4046
angstrom	meter	1×10^{-10}
atmosphere	newton/meter^2	1.013×10^5
calorie (thermochemical)	joule	4.184
curie	disintegration/second (= Bq)	3.7×10^{10}
day (mean solar)	second (mean solar)	8.64×10^4
degree (angle)	radian	1.745×10^{-2}
dyne	newton	1×10^{-5}
electron volt	joule	1.602×10^{-19}
erg	joule	1.0×10^{-7}
erg/cm^{2}s	watt/m^2	1.0×10^{-3}
Fahrenheit (temperature)	Kelvin	$t_k = (5/9)(t_F + 459.67)$
faraday	coulomb	9.649×10^4
foot	meter	3.048×10^{-1}
foot-candle	lumen/meter^2	1.076×10^1
gallon (UK)	meter^3	4.546×10^{-3}
gallon (U.S.)	meter^3	3.785×10^{-3}
gauss	tesla	1.0×10^{-4}
inch	meter	2.54×10^{-2}
kilocalorie (thermochemical)	joule	4.184×10^3
millibar	newton/meter^2	1.0×10^2
millimeter of mercury (0 °C)	newton/meter^2	1.333×10^2
minute (angle)	radian	2.909×10^{-4}
pint (U.S. liquid)	meter^3	4.732×10^{-4}
poise	newton second/meter^2	0.10
psi	newton/m^2	6.894×10^3
rad (radiation dose absorbed)	joule/kilogram	1.0×10^{-2}
roentgen	coulomb/kilogram	2.5798×10^{-4}
second (angle)	radian	4.848×10^{-6}
torr (0 °C)	newton/meter^2	1.333×10^2
watt/cm^2	watt/m^2	1.0×10^4
yard	meter	9.144×10^{-1}

E. Special instructions

The journal would prefer to print full names of authors. Please spell out your first and middle names as well.

Although we have a long list of reviewers on all aspects of photosynthesis, authors are requested to suggest names (with addresses, if possible) of 2 or 3 reviewers when submitting their papers.