Units, symbols, abbreviations

Below are lists of the most common quantities, units, symbols, and abbreviations used in plant-biological research. *Planta* authors are asked to follow these lists. The symbols should be written in upright (Roman) type. If a symbol is derived from a proper name the first letter is written as a capital letter (e.g. A, Bq); otherwise the symbols are written in lower case. They are *not* followed by a period (full stop) and do *not* change in the plural. Products of two symbols should be written in the following way: sA. If a derived unit is formed from two or more units by division it should be written in the following way: m s^{-1}, m/s, kg m^{-2} s^{-1} but *not* kg/m^2/s.

1.SI (International System of Units) base units and symbols					
Quantity	*Unit*	*Symbol*	*Quantity*	*Unit*	*Symbol*
Amount of substance *(N)*	mole	mol	Luminous intensity	candela	cd
			Mass *(m)*	kilogram	kg
Electric current *(I)*	ampere	A	Temperature *(T)*	kelvin	K
Length (*l*)	meter	m	Time *(t)*	second	s

2. Important derived SI units			
	Unit	*Symbol*	*Equivalent in SI units*
Electric charge, quantity of electricity	coulomb	C	1 C= 1 A s=1 J V^{-1}
Electric potential, potential difference	volt	V	l V= l J A^{-1} s^{-1} = l W A^{-1}
Electric resistance	ohm	Ω	1 Ω = m^2 kg s^{-3} A^{-2}
Energy, work, quantity of heat	joule	J	1 J= 1 W s=1 kg m^2 s^{-2}
	electron volt	eV	1 eV= 1.602 × 10^{-19} J
Force	newton	N	1 N = 1 kg m s^{-2}
Frequency	hertz	Hz	s^{-1}
Light flow, luminous flux	lumen	lm	1 lm = 1 cd sr (sr = steradian)
Light flux, illuminance	lux	lx	1 lx=1 lm m^{-2}
Power, radiant flux	watt	W	1 W= 1 kg m^2 s^{-3}
Pressure, stress	pascal	Pa	1 Pa= 1 N m^{-2}= 1 kg m^{-1} s^{-2}
Radioactive disintegrations	becquerel	Bq	l Bq = 1 s^{-1}

3. Units for photochemically active radiation			
Energy fluence	J m^{-2}	Light quantity - photometric	lm s
Energy flow	J s^{-1}	Particle (photon) flow	mol s^{-1}
Energy fluence rate	J m^{-2} s^{-1} = W m^{-2}	Particle (photon) fluence	mol m^{-2}
Energy quantity	J	Particle (photon) fluence rate (flux)	mol m^{-2} s^{-1}
Fluence - photometric	lm m^{-2} s		

4. Units for transport phenomena	
Flow (*I*)	mol s^{-1} or m^3 s^{-1}
Flux (*J*)	mol m^{-2} s^{-1} or m^3 m^{-2} s^{-1}

5. Other processes (for example, chemical reactions, growth) are characterized by:	
Catalytic activity (in enzyme reactions)	mol s^{-1} = kat
Light irradiance	mol^{-2} s^{-1}
Velocity (phenomena of movement)	m s^{-1}

6. Frequently used physiological units (not contained in but accepted under the SI)	
Absorbance (*A*)	log I_0/I
	(I_0, incident quantum flux; I, transmitted quantum flux)
Absorptance	$(I_0 - I)/I_0$

The expression "absorption" is commonly used as an inclusive term for absorbance and absorptance

	Unit	*Symbol*	*Equivalent in SI units*
Concentration (*c*)			
Molarity	mole per liter of solution	M	mol l^{-1}, mol dm^{-3}
Molality	mole per kg of solvent		mol kg^{-1}
Osmolality	mole of osmotically effective		osmol kg^{-1}
	particles per kg of solvent (water)		
Molecular mass ("molecular weight")	gram per mole		10^{-3} kg mol^{-1}
Particle mass	dalton	Da	1 dalton = 1.6605×10^{-27} kg
Pressure (*P*)	bar	bar	1 bar = 10^5 Pa = 10^5 N m^{-2}
Sedimentation constant	svedberg	S	1 S = 10^{-13} s
Temperature (*T*)	degree Celsius	°C	$0°C \hat{=} 273.15K$
Time(*t*)	minute	min	
	hour	h	
	day	d	
Volume, liquid (*V*)	liter	L, 1	1 l= 10^{-3} m^3

7. Conversion factors for units which have been widely used but are no longer allowed under SI					
Unit	*Symbol*	*Conversion to SI units*	*Unit*	*Symbol*	*Conversion to SI units*
ångström	Å	1 Å = 10^{-10} m = 10^{-1} nm	einstein	E	1 E = 1 mol photons
atmosphere	at	1 at (760 mm Hg) = 1.013×10^5 Pa = 1.013 bar	erg	Erg	1 erg = 10^{-7} J (1 erg cm^{-2} s^{-1} = 10^{-3} W m^{-2})
calorie	cal	1 cal = 4.1868 J	rad	rd	1 rd = 0.01 J kg^{-1}
curie	Ci	1 Ci = 3.77×10^{10} Bq	roentgen	R, r	1 R = 2.58×10^{-4} C kg^{-1}
			torr	torr	$1\text{torr} = \frac{101125}{760}\text{Pa}$

8. Multiples of units (prefixes)					
peta-(P)	10^{15}	hecto-(h)	10^2	micro-(μ)	10^{-6}
tera-(T)	10^{12}	deka-(da)	10^1	nano-(n)	10^{-9}
giga-(G)	10^9	deci-(d)	10^{-1}	pico-(p)	10^{-12}
mega-(M)	10^6	centi-(c)	10^{-2}	femto-(f)	10^{-15}
kilo-(k)	10^3	milli-(m)	10^{-3}		

9. Some fundamental constants			
Avogradro's number	$N = 6.022 \times 10^{23}$ mol^{-1}	Gas constant	$R = k\,N = 8.314$ J mol^{-1} K^{-1}
Boltzmann's constant	$k = R\,N^{-1} = 1.381 \times 10^{-23}$ J K^{-1}	Gravitational acceleration (sea level, 45° latitude)	$g = 9.806$ m s^{-2}
Elementary electric charge	$e = F\,N^{-1} = 1.602 \times 10^{-19}$ C (= A s)	Planck's constant	$h = 6.626 \times 10^{-34}$ J s
Faraday constant	$F = e\,N = 9.649 \times 10^4$ C mol^{-1} (= A s mol^{-1} = J V^{-1} mol^{-1})	Velocity of light	$e = 2.998\ 10^8$ m s^{-1}

10. Abbreviations

a) Authors are requested to observe the following rules for the use of abbreviations:

- Avoid using abbreviations in the main title.
- Abbreviations should be given only for terms used at least four times.
- Abbreviations used repeatedly throughout the paper should be listed alphabetically in an unnumbered footnote on the title page. Those used only in one section of the paper need not be included in the list.
- Avoid the use of more than five abbreviations in addition to those used in list *b)* and those marked * in list *c)*
- As far as possible, use only widely recognized abbreviations which are given under *b)* and *c).*

- On first appearance in the text or abstract, each term should be given in full, with abbreviation following in parentheses.
- An abbreviation should not be used as the first word of the sentence or heading. Spell out, or rephrase the sentence.
- Avoid the use of abbreviations which could be confused with widely accepted symbols.

b) General terms. These can be used without explanation, with the following reservations: * only in the tables, figures, figure captions; ** only if associated with a numeral, and in tables etc.; *** only if part of a binominal or following one

Absorbance	A**	Concentration	concn.*
Approximately	approx. (or ca.)	Counts per minute	cpm
**b (bp)	bases (base pairs)	Cultivar	cv.***
Calculated	calc.*	Diameter	diam
compare	cf.	Dry weight	DW
Equation	Eq.**	Parts per million	ppm; *or*
Equilibrium constant	*K*		for solutions: mg l^{-1}
Figure(s)	Fig(s).		for gases: μ l^{-1}
Fresh weight	FW	Pyrophosphate	PPi
Hydrogen ion concentration,	pH	Probability	*P***
negative logarithm		Relative molecular mass	M_r**
Inner diameter	i.d	Respiratory quotient	RQ**
Isoelectric point	pI**	Retardation factor	R_f**
Least significant difference	LSD	Revolutions per minute	rpm** (rev min^{-1})
Maximum velocity	V_{max}	Species (taxonomic)	sp., plural spp.***
Michaelis constant	K_m	Standard deviation	SD
Molecular weight	MW**	Standard error of the mean	SE
Months (only in dates,	First three letters	Temperature quotient(10 °C)	Q_{10}
tables, figures)		Ultraviolet	UV
Number	No.**	Variety (taxonomic)	var.***
Number, in statistics	*n*	Volume(s)	vol.**
Observed	Obs.*	Volume/volume (solvents)	v/v; if more than two:
Orthophosphate	Pi		by vol.
Outer diameter	o.d	Wavelength	λ**
Per cent	%**	Weight/volume (solvents)	w/v

c) Chemicals, and some related terms. Those marked * can be used without explanation; all others should be explained

*ABA	*cis*-abscisic acid (*not* AbA)	CCCP	carbonylcyanide *m*-chlorophenylhydrazone
(Ac)	(acetyl) – *do not use*	*Chl	chlorophyll
ActD	actinomycin D	Chlide	chlorophyllide
*ADP	adenosine 5'-diphosphate	*cDNA	copy DNA
AM	arbuscular mycorrhiza	CDP	cytidine 5'-diphosphate
*AMP	adenosine 5'-monophosphate	CHM	cycloheximide
*ATP	adenosine 5'-triphosphate	CM-celluose	O-carboxymethylcelluose
*ATPase	adenosine triphosphatase	*CMP	cytidine 5-monophosphate
		CMU	3'-(4-chlorophenyl)-1',1-dimethylurea(monuron)
BA	N^6-benzyladenine	*CoA	coenzyme A
*Bicine	N,N-bis(2-hydroxyethyl)glycine	cpDNA	chloroplast DNA
*Bistris	2-[bis(2-hydroxyethyl)amino]-2-(hydroxymethyl)-1,3-propanediol	*CTP	cytidine 5'-triphosphate
BrdUrd	5-bromodeoxyuridine		
*BSA	bovine serum albumin	2,4-D	2,4-dichlorophenoxyacetic acid
BU	5-bromouracil	DAPI	4',6-diamidino-2-phenylindole
		*DCMU	3-(3',4'-dichlorophenyl)-1,1-dimethylurea (diuron)
CAM	crassulacean acid metabolism	*DEAE-cellulose	diethylaminoethylcellulose
*cAMP	adenosine 2':3'-cyclic monophosphate	*DMSO	dimethyl sulfoxide

*DNA	deoxyribonucleic acid	*IAA	indole-3-acetic acid, indol-3-ylacetic acid
*DNase	deoxyribonuclease	2iP	N^6-Δ^2-isopentenyladenine
DNP	2,4-dinitrophenol	IR	infra-red
DOPA	dihydroxyphenylalanine		
DPIP	2,6-dichlorophenol indophenol	JA	jasmonic acid
dsDNA	double-stranded DNA		
dry ice	use: solid CO_2	Kin	kinetin(N^6-furfurylaminopurine)
*DTT	dithiothreitol		
		MAPK	mitogen activated protein kinase
*EDTA	ethylenediaminetetraacetic acid, – acetate	(Me)	(methyl) - *do not use*
*EGTA	ethylene glycol-bis(β-aminoethyl-ether)-N, N,N',N'-tetraacetic acid, – acetate	*Mes	2-(N-morpholino)ethanesulfonic acid
ELISA	enzyme-linked immunosorbent assay	*Mops	3-(N-morpholino)propanesulfonicacid
EPR	electron paramagnetic resonance	*mRNA	messenger RNA
*ER	endoplasmic reticulum	MS	mass spectrometry
EST	expressed sequence tag	mtDNA	mitochondrial DNA
(Et)	(ethyl) - *do not use*	MVA	mevalonic acid, mevalonate
		m/z	mass-to-charge ratio
*FAD,	flavine-adenine dinucleotide: oxidized and		
$FADH_2$	reduced forms	NAA	α-naphthaleneacetic acid, naphthalene-1-acetic acid
FC	fusicoccin		
FCCP	carbonyl cyanide *p*-(trifluoromethoxy)-phenylhydrazone	β-NAA	β-naphthaleneacetic acid, naphthalene-2-acetic acid
Fd	ferredoxin		
FdUrd	5-fluorodeoxyuridine	*NAD	nicotinamide adenine dinucleotide, nicotinamide adenine dinucleotide phosphate, and their reduced forms
FITC	fluorescein isothiocyanate	(or NAD^+)	
*FMN	flavine mononucleotide, riboflavin 5'-phosphate	*NADH	
FR	far-red light	*NADP	
FU	5-fluorouracil	($NADP^+$)	
		*NADPH	
GABA	gamma-aminobutyric acid	NMR	nuclear magnetic resonance
		nRNA	nuclear RNA
GA, GA_1 ...	gibberellin, gibberellin A_1		
GA_3	gibberellic acid *(not* gibberellin A_3)	OAA	oxaloacetic acid
*GC-MS	gas chromatography-mass spctrometry	(OAc)	(acetate) - *do not use*
GDP	guanosine 5'-diphosphate	ORF	open reading frame
GLC	gas-liquid chromatography	*PAGE	polyacrylamide gel electrophoresis
*GMP	guanosine 5'-monophosphate	PAL	phenylalanine ammonia-lyase
GO	gene ontogeny	PAR	photosynthetically active radiation
GOGAT	glutamate synthase	PCMB	*p*-chloromercuribenzoate
GSH, GSSG	glutathione, reduced and oxidized forms	PCMBS	*p*-chloromercuribenzenesulfonic acid
*GTP	guanosine 5'-triphosphate	PCR	polymerase chain reaction
GUS	β-glucuronidase	*PEG	polyethyleneglycol
		PEP	phosphoenolpyruvic acid, – pyruvate
*Hepes	4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid	PEPCase	phosphoenolpyruvate carboxylase
*Hepps	4-(2-hydroxyethyl)-1-piperazinepropanesulfonic acid	*PFD	photon flux density
*HPLC	high-performance liquid chromatography	Pfr	far-red-absorbing form of phytochrome

PGA	3-phosphoglyceric acid, – glycerate	*Tris	2-amino-2-(hydroxymethyl)-l,3-propanediol
PGPR	plant-growth-promoting rhizobacteria	*tRNA	transfer RNA
*Pipes	1,4-piperazinediethanesulfonic acid		
PMSF	phenylmethylsulfonylfluoride	*UDP	uridine 5'-diphosphate
*poly(A)RNA	polyadenylated RNA	*UMP	– 5'-monophosphate
*poly(A)$^+$ RNA	polyadenylated RNA	*UTP	– 5'-triphosphate
*poly(A)$^-$RNA	non-polyadenylated RNA		
POPOP	l,4-bis(5-phenyloxazoyl)benzene	Ψ (Capital Greek psi)	water potential; $-_s$ = osmotic potential:
*PPFD	photosynthetic photon flux density		$-_p$ = pressure potential: $-_m$ = matric potential;
PPO	2.5-diphenyloxazole		$-_{leaf}$ = leaf water potential; etc.
PQ	Plastoquinone	ψ (lower case psi)	electric potential difference
Pr	red-absorbing form of phytochrome		
PR	pathogenesis-related	Φ	flux (ion, mass, solute)
*PSI, PSII	photosystem I, – II		
Pftot	total phytochrome (Pr + Pfr)		
PVDF	polyvinylidenedifluoride		
PVPP	polyvinylpolypyrrolidone		
QTL	quantitative trait locus		
R	red light		
*RACE	rapid amplification of cDNA ends		
rER	rough endoplasmic reticulum		
RFLP	restriction fragment length polymorphism		
*RNase	ribonuclease		
*RNA	ribonucleic acid		
rRNA	ribosomal RNA		
*RT-PCR	reverse transcription PCR		
RuBP	ribulose-l,5-bisphosphate		
*Rubisco	ribulose-l,5-bisphosphate carboxylase/oxygenase		
SA	salicylic acid		
SAM	shoot apical meristem		
*SDS	sodium dodecyl sulfate		
sER	smooth ER		
sDNA	single-stranded DNA		
SNP	single nucleotide polymorphism		
*Taps	3-{[2-hydroxy-l,l-bis(hydroxymethyl)ethyl]-amino}-l-propanesulfonic acid		
TCA	trichloroacetic acid		
(TCA Cycle)	(tricarboxylic-acid cycle) - *spell out*		
*Tes	2-{[2-hydroxy-l,l-bis(hydroxymethyl)ethyl]-amino}ethanesulfonic acid		
*TLC	thin-layer chromatography		
TMV	tobacco mosaic virus		
Tria	triacontanol		
*Tricine	N-[2-hydroxy-l,l-bis(hydroxymethyl)ethyl]-glycine		

Amino acids, monosaccharides, purines and pyrimidines. Three-letter symbols, and one-letter symbols of amino acids, to be used only in representing polymers and sequences: if used otherwise (e.g. in papers dealing with one or a few amino acids etc.) they should be explained

alanine	Ala	A	hydroxyproline	Hyp	-
arginine	Arg	R	isoleucine	Ile	I
asparagine	Asn	N	leucine	Leu	L
aspartic acid	Asp	D	lysine	Lys	K
asparagine *or* aspartic acid (unidentified)	Asx	B	methionine	Met	M
			ornithine	Orn	-
cysteine	Cys	C	phenylalanine	Phe	F
glutamine	Gln	Q	proline	Pro	P
glutamic acid	Glu	E	serine	Ser	S
glutamine *or* glutamic acid (unidentified)	Glx	Z	threonine	Thr	T
glycine	Gly	G	tryptophan (*not* tryptophane)	Trp (*not* Try)	W
histidine	His	H	tyrosine	Tyr	Y
hydroxylysine	Hyl	-	valine	Val	V
arabinose	Ara		glucose	Glc (*not* Glu)	
2-deoxyribose	dRib		mannose	Man	
fructose	Fru		ribose	Rib	
fucose	Fuc		xylose	Xyl	
galactose	Gal				

Phosphorylated derivatives: Glc6P, Fru 1,6bisP, etc.
Nucleotide-diphosphate sugars: UDPGlc, GDPMan, etc.

adenine	Ade	purine, unknown	Pur
cytosine	Cyt	pyrimidine, unknown	Pyr
guanine	Gua	thymine	Thy
hypoxanthine	Hyp	uracil	Ura
orotate	Oro	xanthine	Xan

Structural analogs - in italics

ortho	*o*	para	*p*	secondary	*sec*	*cis-*
meta	*m*	normal	*n*	tertiary	*tert*	*trans-*

Isotopes. For simple molecules it is usually sufficient to indicate labelling by writing the isotope in the chemical formula, e.g. $^{14}CO_2$, $H_2{}^{18}O$, $^{2}H_2O$, $H_2{}^{35}SO_4$.
For other molecules the isotope is placed in square brackets directly in front of the name, without hyphen or space: [^{3}H]leucine, [^{14}C]ATP. However, in case of generic names etc., the isotope is written without brackets and followed by a hyphen: ^{14}C-photosynthate, ^{3}H-amino acids.
The positions of isotopic labelling are indicated by Arabic numerals, Greek letters, or prefixes placed in the bracket: [3-^{14}C]serine, [1,7,12,18-^{14}C] gibberellic acid. The symbol U indicates uniform labelling G indicates general labelling. e.g.[U-^{14}C]glucose is ^{14}-C-labelled in all six positions and the label distributed among these uniformly; [G-^{14}C]glucose is also labelled in all six positions but not uniformly.
Letters and numerals indicating isomers and the like are not included in the brackets: L-[^{14}C]leucine, D-[U-^{14}C]glucose, *o*-[^{14}C]chlorophenol, α-[^{14}C]NAA, indole-3-[2-^{14}C]acetate.