Norman McCormick and Curtis Mobley contributed to this page.

This page gives brief definitions of many terms used in optical oceanography. Where appropriate, links are provided to pages where terms are discussed in more detail.

absorbance: The (base 10) logarithm of the ratio of the radiant power at a given wavelength incident onto a volume to the sum of the scattered and directly transmitted radiant powers emerging from the volume; also called optical density. Nondimensional. Further discussion on the pages for IOPs , benchtop spectrophotometry., and benchtop spectrophotometry of particulates.

absorptance: The fraction of the incident power at a given wavelength that is absorbed within a volume. Nondimensional. See absorbance above for links to further discussion. Further discussion

absorption: Any process whereby radiant energy is converted to non-radiant energy, e.g., to thermal, chemical, vibrational, or rotational energy of a molecule. Absorption results in the disappearance of photons.

absorption coefficient: The absorptance per unit distance of photon travel in a medium, i.e., the limit of the ratio of the spectral absorptance to the distance of photon travel as that distance becomes vanishingly small. Units: $[m^{-1}]$. See also diffuse absorption coefficient and specific absorption coefficient. Further discussion.

albedo of a surface: The ratio of the plane irradiance leaving a surface to the plane irradiance incident onto it, i.e., the ratio of the upwelling plane irradiance to the downwelling plane irradiance, with both measured just above the surface. Nondimensional.

albedo of single scattering: The probability of a photon surviving an interaction; equals the ratio of the scattering coefficient to the beam attenuation coefficient. Nondimensional. Further discussion and application in Monte Carlo simulations.

algae: Any of various eukaryotic, photosynthetic organisms containing chlorophyll but lacking true roots, stems, and leaves. Sizes range from single-celled phytoplankton to giant kelp. Previously grouped with plants, but now often classified separately.

anisotropic scattering: Scattering that is not spherically symmetric (not isotropic).

aphotic zone: That portion of the ocean where light is insufficient for plants to carry on photosynthesis.

apparent optical property (AOP): An optical quantity that depends weakly on the external environment (e.g., sun angle or surface waves) but strongly on the water absorption and scattering properties (IOPs), and therefore can be used to describe the water body via optical measurements. Most AOPs are either ratios of radiometric quantities (e.g., reflectances) or depth derivatives of radiometric quantities (e.g., diffuse attenuation functions). Radiometric variables themselves (e.g., radiance or irradiances) are *not* AOPs. Dimensions vary. Further discussion.

asymmetry parameter: In scattering, the average cosine of the scattering angle. The asymmetry parameter measures how strongly a medium scatters light in the forward direction; it is zero for isotropic scattering. Further discussion

asymptotic diffuse attenuation coefficient: The value of the diffuse attenuation coefficient in the asymptotic regime. Diffuse attenuation coefficients for radiance and the associated irradiances all have the same value in the asymptotic regime; that value depends only on the inherent optical properties. See diffuse attenuation coefficients. Units: $[m^{-1}]$. Further discussion.

asymptotic radiance distribution: The angular shape of the radiance distribution (normalized to 1 at the maximum value) at depths far from the boundaries of a homogeneous medium. The asymptotic radiance distribution is determined only by the inherent optical properties. The directional and depth dependencies of the asymptotic radiance distribution decouple and all radiometric variables (e.g., irradiances) change with depth at the same rate as the radiance. Nondimensional. Further discussion.

attenuation coefficient: See beam attenuation coefficient and diffuse attenuation coefficient.

average cosine: See mean cosine of radiance or scattering. Nondimensional.

back scattering: Scattering through angles greater than 90 degrees relative to the incident (unscattered) direction.

backscattering coefficient: The integral of the volume scattering function over the hemisphere of backscattered directions. Units: [m^{-1}]. Further discussion.

backscattering fraction: The ratio of the backscattering coefficient to the scattering coefficient. Nondimensional. Further discussion.

beam attenuation coefficient: The limit of the ratio of the spectral absorptance plus spectral scatterance to the distance of photon travel as that distance becomes vanishingly small; equal to the sum of the absorption and scattering coefficients. Units: [m^{-1}]. Further discussion.

beam spread function: The irradiance distribution on the inner surface of a sphere as generated by an initially collimated, narrow beam emitted at the center of the sphere and normalized to the emitted beam power; numerically equals the point spread function. Units: [m^{-2}]. Further discussion.

beam transmissometer: An instrument that measures the fraction of power emitted in a collimated beam that is lost by absorption and scattering out of the beam per unit distance of photon travel; measures the beam attenuation coefficient.

Beer's law: The statement that radiation traveling in a certain direction in a scattering or absorbing medium is exponentially attenuated with distance traveled.

benthic: Refers to the bottom of a water body and to the organisms that live in or on the bottom of the ocean (the benthos).

benthos: Bottom-dwelling marine organisms.

bidirectional reflection distribution function (BRDF): The ratio of the radiance reflected by a surface into a specific direction to the collimated irradiance incident from a particular direction onto the surface. Units: [sr^{-1}]. Further discussion.

bio-geo-optical models: Analytical and numerical models that parameterize the absorption and scattering properties of water constituents (phytoplankon, CDOM, minerals, etc.) in terms of the concentrations of those consituents (e.g., chlorophyll *a* concentration, mass concentration of mineral particles) or other parameters (e.g, the CDOM absorption at one wavelength). Further discussion.

bioluminescence: Light produced by living organisms via conversion of chemical energy to radiant energy.

biomass: The amount of living matter per unit of water surface or water volume (i.e., in the water column). Units: [$kg\ m^{-2}$] or [$kg\ m^{-3}$].

black-body radiation: Refers to the spectral shape of electromagnetic radiation within or emitted by an object in thermal equilibrium with its environment. The black-body spec-

trum is independent of the emitting material and depends only on the temperature of the emitting body. Further discussion.

Bouguer-Lambert law (Bouguer's law): See Beer's law.

broad-band: Refers to the amount of radiant energy contained in a finite wavelength interval. Thus broad-band irradiance is the power per unit area in some wavelength interval. Instruments have finite bandwidths and thus measure broad-band quantities. See spectral.

BSF: See beam spread function.

Case 1 water: Water whose absorption and scattering properties are determined primarily by phytoplankon and their degradation products (detritus and CDOM). The IOPs of Case 1 water are often (but imperfectly) parameterized by the chlorophyll concentration. Case 1 water is not a synonym for open ocean water. Further discussion.

Case 2 water: Water whose absorption and scattering properties are significantly influenced by mineral particles or CDOM not derived from phytoplankton (e.g., CDOM from terrestrial runoff or benthos), so that the IOPs do not correlate well with the chlorophyll concentration. Case 2 water is not a synonym for open coastal water. Further discussion.

capillary wave: A water wave for which the primary restoring force is surface tension; waves with wavelengths less than 1.7 cm are considered capillary waves.

chlorophyll: Chemical compounds occurring in plants that enable radiant energy to be converted to chemical energy in the process of photosynthesis; there are several types denoted as chl *a*, chl *b*, etc., with chl *a* typically the most abundant and often used as a proxy for phytoplankton biomass.

closure: In optical oceanography, a generic term referring to consistency of models and measurements. The types of closure are

measurement closure Making consistent measurements. Example are (1) Agreement among different instruments or methodologies that measure the same quantity; (2) Having measurements of the absorption and scattering coefficients sum to a measured value of the beam attenuation coefficient, as they should by definition, and (3) Having a measurement of the scattering coefficient equal the integral over all directions of a measured volume scattering function.

model closure Having consistent models. An example is having various computer programs that solve the radiative transfer equation all give the same output for the same inputs.

model-data closure Agreement between predictions made by models and measurements of the predicted quantity. An example is having a computer model predict the same in-water irradiance distribution as is measured.

scale closure Agreement between measurements of a given quantity made at different spatial or temporal scales. An example is having a satellite-derived (large spatial scale) absorption coefficient agree with a measurement made in situ by an instrument sampling a small volume of water.

coastal water: Generally refers to water situated over continental shelves; often, but not always, Case 2 water.

Coastal Zone Color Scanner (CZCS): A multi-spectral scanning radiometer aboard the Nimbus-7 satellite; operational from October 1978 to June 1986. CZCS had four channels devoted to ocean color, each of 20 nm bandwidth and centered at 443, 520, 550, and 670 nm. This sensor pioneered remote sensing of the oceans at visible wavelengths. Further discussion.

colored dissolved organic matter (CDOM): High-molecular-weight organic compounds (humic and fulvic acids) formed from the decomposition of plant tissue; they strongly absorb light at the blue end of the spectrum and can give water a yellowish color at high concentrations. Also called chromophoric dissolved organic matter, yellow matter, gilvin, or Gelbstoff. Further discussion.

cosine collector: A radiant energy detector whose effective light collection area is proportional to the cosine of the angle between the incident light and the normal to the detector surface; used to measure plane irradiances. Further discussion.

Coulter Counters: A class of instruments that counts particles and measures particle size distributions from the change in electrical conductivity as particles flow through a small orifice in an electrolyte (such as water). Originally developed by Coulter Electronics, now marketed by Beckman Coulter, Inc..

cross section: Any of several quantities with units of area, which describe the interaction of an object with an incident flux of particles or radiation. Commonly used cross sections are

absorption cross section The cross sectional area of a beam of light containing power equal to the power absorbed by a particle in the beam. Units: $[m^2]$.

geometric cross section The physical cross sectional area of a particle. Units: $[m^2]$.

scattering cross section The cross sectional area of a beam of light containing power equal to the power scattered by a particle in the beam. Units: $[m^2]$.

critical depth: The depth in the water column below which respiratory carbon loss by phytoplankton exceeds photosynthetic carbon gain; no net phytoplankton production occurs. Units: [m].

euphotic depth: The maximum depth in the water column to which significant phytoplankton photosynthesis can take place. Units: [m].

detritus: The particulate decomposition or disintegration products of plankton, including dead cells, cell fragments, fecal pellets, shells, and skeletons; sometimes considered to include inorganic mineral particles.

diel: Refers to occurrences on a 24 hour cycle; any periodic diurnal (daytime) or nocturnal (nighttime) cycle.

diffuse: Refers to radiance distributions resulting from so many multiple scatterings of the photons that the source location (e.g., the sun) cannot be discerned. A diffuse radiance distribution does not imply an isotropic distribution (e.g., an asymptotic radiance distribution is diffuse but not isotropic). See isotropic.

diffuse absorption coefficient: For downwelling (upwelling) irradiance: the ratio of the absorption coefficient to the mean cosine of the downward (upward) radiance. Units: $[m^{-1}]$.

diffuse attenuation coefficients: The negative of the derivative with respect to depth of the natural logarithm of a radiometric variable (e.g. radiance, downwelling or upwelling irradiance). Also called K functions. Units: [m^{-1}]. Further discussion.

dissolved organic matter: See colored dissolved organic matter.

diurnal: Refers to occurrences during the day, as opposed to nocturnal occurrences; sometimes incorrectly used for diel occurrences.

divergence law for irradiance: See Gershun's law.

einstein: One mole (Avogadro's number) of photons, equal to 6.023×10^{23} photons.

efficiency factor: The ratio of an optical cross section to the geometric cross section of a particle; a measure of how effectively a particle removes light from a collimated beam through processes of absorption or scattering. Nondimensional. Also called Q factors. Further discussion.. The commonly used efficiency factors are

efficiency factor for absorption The ratio of the absorption cross section to the geometrical cross section of the particle. Nondimensional.

efficiency factor for attenuation The ratio of the attenuation cross section to the geometrical cross section of the particle; equals the sum of the efficiency factors for absorption and scattering. Nondimensional.

efficiency factor for scattering The ratio of the scattering cross section to the geometrical cross section of the particle. Nondimensional.

elastic scattering: Any process that leads to a change in the direction of propagation of light without a change in energy of the scattered photons; includes volume scattering within a medium and reflection and refraction at the surface of a medium. Further discussion.

eukaryote: A cellular organism in which the genetic material is contained within a nucleus; includes algae and all more complex life forms. See prokaryote.

euphotic zone: The upper region of a water body in which significant phytoplankton photosynthesis can take place; often (but inaccurately) taken to be the layer down to which photosynthetically available radiation *at noon* falls to 1% its value just below the sea surface.

eutrophic water: Water with high phytoplankton biomass; chlorophyll *a* concentration exceeds 10 mg m^{-3}.

fluorescence: An inelastic scattering process in which a photon is absorbed by a molecule and shortly thereafter (10^{-11} to 10^{-8} s) another photon of greater wavelength is emitted; the emitted radiance is isotropic and unpolarized. Further discussion.

Forel-Ule color scale: A method of visually determining the color of a water body by comparing the water color with a set of 21 chemical solutions having colors from blue to green to brown. The resulting Forel-Ule color index (a number from 1 to 21) is a crude measure of the water composition. Although largely replaced by modern instruments that give quantitative data, the Forel-Ule color measurements are still of interest because of the large historical database of observations going back over a century. Nondimensional. Further discussion.

Fournier-Forand phase function: An analytical model for scattering phase functions derived by integrating the Mie scattering solution over all sizes of particles for an assumed

Junge size distribution. The inputs to the formulas are the index of refraction of the particles and the slope of the Junge distribution. The Fournier-Forand phase function has largely replaced the Petzold phase functions for numerical simulations. Units: [sr^{-1}] Further discussion.

Fresnel reflectance: The fraction of radiant energy in a collimated beam that is reflected from a level surface at which there is an index of refraction mismatch. Nondimensional. Further discussion.

fulvic substance: High molecular weight organic compounds resulting from plant decay, especially phytoplankton; one component of colored dissolved organic matter.

gelbstoff: See colored dissolved organic matter.

Gershun's law: An equation expressing conservation of energy derived by integrating the monochromatic radiative transfer equation (for a medium with no inelastic scattering or internal sources) over all directions; it states that the depth derivative of the net plane irradiance equals the negative of the absorption coefficient multiplied by the scalar irradiance. Further discussion.

Gershun tube: A tube used to limit the field of view of a radiometer to a small solid angle; used in measuring radiances. Further discussion.

gilvin: See colored dissolved organic matter.

gravity wave: A water wave in which the primary restoring force is gravity; waves with wavelengths greater than 1.7 cm are considered gravity waves.

Henyey-Greenstein phase function: An analytical model for scattering phase functions that parameterizes the shape of the phase function via the asymmetry parameter (the average cosine of the scattering angle). Although sometimes used in atmospheric optics, it does not give a good description of oceanic scattering at very small and very large scattering angles and is therefore not recommended for use in optical oceanography. Units: [sr^{-1}] Further discussion.

humic substance: High molecular weight organic compounds resulting from plant decay, especially terrestrial plants; see colored dissolved organic matter.

real index of refraction: The ratio of the speed of light in a vacuum to its speed in a material medium; governs how light is scattered (refracted) when crossing an interface between materials with different indices of refraction. Further discussion.

complex index of refraction: A complex number that combines the real index of refraction as the real part, and a term related to the absorption coefficient as the imaginary part; useful is mathematical description of light propagation in material media. Further discussion.

inelastic scattering: Scattering in which the wavelength of the light changes because radiant energy is transferred to the scatterer; the direction of propagation may or may not change. Further discussion on the Raman Scattering and Fluorescence pages.

inherent optical property (IOP): In optical oceanography, any optical quantity that depends only on the properties of the water and is independent of the ambient light field; the absorption coefficient and the volume scattering function are the fundamental IOPs. Apparent optical properties become inherent optical properties as the depth increases and the radiance distribution becomes asymptotic. Further discussion.

(spectral) intensity: The radiant spectral power in a given direction per unit solid angle per unit wavelength interval. Intensity is used to describe the light emitted by point

sources and in the definition of the volume scattering function. Units: [W sr^{-1} nm^{-1}]. Further discussion.

inverse problems A general class of problems in which optical measurements are used to infer inherent optical properties of the medium or the nature of internal sources. Further discussion.

(spectral) irradiance: The radiant power per unit area per unit wavelength interval. Units [W m^{-2} nm^{-1}]. Further discussion.. The commonly used irradiances are

downward (upward) plane irradiance The downward (upward) directed radiant power per unit area onto an upward (downward) facing horizontal surface. Units: [W m^{-2} nm^{-1}].

net plane irradiance The downward plane irradiance minus the upward plane irradiance. Units: [W m^{-2} nm^{-1}].

scalar irradiance The radiant power per unit area from all directions onto a spherical collecting surface. Units: [W m^{-2} nm^{-1}].

downward (upward) scalar irradiance The downward (upward) directed radiant power per unit area onto a spherical collecting surface that is shielded from light traveling upward (downward). [W m^{-2} nm^{-1}]

irradiance reflectance or irradiance ratio: The ratio of the upward plane irradiance to the downward plane irradiance. Nondimensional. Further discussion.

isotropic: An adjective meaning equal in all directions, or independent of direction. An isotropic radiance distribution has the same radiance in every direction; isotropic scattering scatters light equally in all directions. Further discussion.

Jerlov water type: A water clarity classification scheme based on the downward diffuse attenuation coefficient just below the sea surface. Further discussion.

Junge particle size distribution: A power-law function often used to describe the particle concentration [particles m^{-3}] per unit size interval [μm] as a function of the equivalent spherical diameter of particles; the number density for particles of equivalent diameter x is proportional to x^{-k}, where k is typically 3 to 5 in natural waters. Some use the term Junge only if $k = 4$; otherwise it is called a power-law distribution. Units: [particles m^{-3} μm^{-1}] Further discussion.

K-function: See diffuse attenuation coefficient.

Lambertian surface: A surface that reflected or emits light at each point of the surface in an angular pattern that is proportional to the cosine of the angle to normal to the surface. When many such points are viewed by a radiometer, the surface as a whole reflects or emits light whose radiance is equal in all directions over the hemisphere. A Lambertian surface is characterized by its irradiance reflectance. Further discussion.

marine snow: In oceanography, living or nonliving particles whose downward drift, in a dense-enough concentration, appears similar to snowfall.

mean cosine of the radiance distribution: The average cosine of the polar angle of all the radiance propagation direction; it equals the ratio of the net plane irradiance to the total scalar irradiance. The mean cosine is zero for an isotropic radiance distribution. Nondimensional. Further discussion.

mean cosine of the downward (upward) radiance: The average cosine of the nadir (zenith) angle of all downward (upward) traveling photons; it equals the ratio of the plane irradiance to the scalar irradiance for the downward (upward) direction. The average cosines are AOPs. Nondimensional. Further discussion.

mean free path: The average distance between photon-matter interactions; it equals the inverse of the beam attenuation coefficient. Units: [m]. Further discussion

mean free path for absorption: The average distance between photon-matter interactions in which photons are absorbed; it equals the inverse of the absorption coefficient. Units: [m].

mean free path for scattering: The average distance between photon-matter interactions in which photons are scattered; it equals the inverse of the scattering coefficient. Units: [m].

mesotrophic water Water with moderate concentrations of phytoplankton biomass;chlorophyll a concentration ranges between 0.5 and 10 mg m^{-3}.

Mie scattering theory: An exact solution of Maxwell's equations that describes the scattering of electromagnetic waves (e.g., light) by homogeneous spheres of any size. Use of the theory requires knowledge of the complex index of refraction of the sphere relative to the surrounding medium and the ratio of the sphere's circumference to the wavelength of light in the medium. Often called Mie scattering, although it is a mathematical model for scattering under certain conditions, not a physical scattering process. Further discussion

Mie size parameter: The ratio of a sphere's circumference to the wavelength of light in the surrounding medium. Further discussion

mixed layer: Near-surface waters subject to mixing by wind and waves; there is little variation in salinity or temperature below the mixed layer.

nadir angle: The angle between a given direction and the downward vertical (nadir) direction. Units: [degrees] or [radians]

nekton: Organisms that can actively swim and are therefore more-or-less free of currents. Compare with plankton.

nocturnal: Pertaining to occurrences during the night, as opposed to diurnal occurrences.

ocean color: A generic term referring to the spectral dependence of the radiance leaving a water body. Further discussion

ocean color sensor: Any instrument for sensing of ocean color, usually from aircraft or satellites. Further discussion

oceanic optics: See optical oceanography.

oligotrophic water: Water with low phytoplankton biomass, typical in many open ocean regions; chlorophyll a concentration is below 0.5 mg m^{-3}.

open ocean: Water sea-ward of the edges of the continental shelves; often, but not always, Case 1 water.

optical constants: The non-negative real and imaginary parts of the complex index of refraction. In spite of their name, the constants depend strongly on wavelength. Further discussion

optical density: See absorbance.

optical depth: The optical distance in the vertically downward direction. Further discussion beginning at radiative transfer equations

optical distance or optical path length: The integral of the product of the beam attenuation coefficient [m^{-1}] multiplied by an infinitesimal unit of distance [m] along the direction of travel. Dimensionless. Further discussion

optical oceanography: The subdiscipline of oceanography concerned with the propagation of radiant energy through sea water and with the interactions of light with sea water constituents. The wavelengths of interest are usually in the 300-1000 nm range. Optical oceanography is closely coupled to other oceanographic subdisciplines because light is fundamental to biology, remote sensing, underwater imaging, heating of the upper ocean, and other applications.

package effect: Refers to the discrepancy between the spectral absorption coefficient of suspension of particles containing a spatially nonuniform distribution of pigment molecules, and the corresponding coefficient of a homogeneous solution containing the same amount of pigment. For the same pigment mass, the absorption spectrum of the non-uniform particles is "flatter" (less peaked) than the uniform suspension of pigment molecules. Further discussion

PAR: See photosynthetically available radiation.

penetration depth: The geometric depth given by 1 over the diffuse attenuation coefficient for downwelling plane irradiance; also called diffuse attenuation depth. The penetration depth is different for different wavelengths because the IOPs depend on wavelength. Relevant to remote sensing because about 90% of the sunlight that enters the ocean and is scattered back out comes from within one penetration depth of the surface. Units: [m]

Petzold's data: A widely used data set containing volume scattering functions measured in various waters ranging from very clear to very turbid; the associated scattering phase functions are highly peaked at small scattering angles. These pioneering data from 1972 are still sometimes used for generic studies of scattering by different water types. Further discussion

phase function: The ratio of the volume scattering function [m^{-1} sr^{-1}] to the scattering coefficient [m^{-1}]; the integral of the phase function over all directions is unity. Units: [sr^{-1}] Further discussion

photosynthesis: The manufacture of carbohydrates from carbon dioxide and water in the presence of chlorophyll, by utilizing radiant energy and releasing oxygen.

photosynthetically available radiation (PAR): The integral over visible wavelengths (usually 400–700 nm, but sometimes 350–700 nm) of the number of photons available for photosynthesis [photons s^{-1} m^{-2}]. PAR is usually computed by integrating the spectral scalar irradiance [W m^{-2} nm^{-1}] divided by the photon energy at each wavelength [W/photon] over wavelength [nm]. Units: [photons s^{-1} m^{-2}], often expressed as [μ mol photons s^{-1} m^{-2}] for convenience of numerical magnitudes. Further discussion

photosynthetic capacity: The maximum photosynthetic rate per unit of biomass.

gross photosynthetic rate: The total rate of carbon dioxide fixation with no allowance made for the CO_2 simultaneously lost in respiration. Units: [μmol CO_2 (mg chl)$^{-1}$ h^{-1}] or [mg C (mg chl)$^{-1}$ h^{-1}].

net photosynthetic rate: The total rate of photosynthetic CO_2 fixation minus the rate of loss of CO_2 in respiration.

specific photosynthetic rate: Photosynthetic rate, net or gross, per unit biomass or per unit volume. Units: [μmol CO_2 (mg chl)$^{-1}$ h^{-1}].

phytoplankton: Small (linear sizes from less than 1 to tens of μm), usually single-cell

(some form chains several hundred μm) long), aerobic (living in oxygenated environments), photosynthetic (pigmented, containing chlorophyll *a*; using sunlight), oxygenic (producing oxygen) organisms; may be prokaryotes (e.g., cyanobacteria) or eukaryotes (e.g., protists and chlorophytes); most are not plants. Further discussion

plankton: Passively drifting or weakly swimming organisms. Compare with nekton.

plankton bloom: An unusually high concentration of phytoplankton, often producing a discoloration of the water body.

point spread function (PSF): The apparent radiance due to an unresolved Lambertian (cosine-emitting) point source, as normalized to the source intensity in the direction of maximum emission; numerically equal to the beam spread function. Units: [m^{-2}]. Further discussion.

polarization: Refers to the orientation of the plane of oscillation of the electric field vector of an electromagnetic wave. The state of polarization is specified by the four components of the Stokes vector. Further discussion.

primary production: The *amount* of organic matter produced from inorganic matter by photosynthesis. Units: [g C m^{-3}] or, for the entire water column, in [g C m^{-2}].

primary productivity: The *rate* of production of organic matter from inorganic matter by photosynthesis. Units: [g C m^{-3} h^{-1}] or, for the entire water column, in [g C m^{-2} h^{-1}]

prokaryote: A cellular organism that lacks a nuclear membrane and thus has its genetic material in strands distributed throughout the cell; includes bacteria. See eukaryote.

PSF: See point spread function.

Q factor: See efficiency factor.

quantum meter or quantum sensor: An instrument that measures the number of photons (e.g.,photosynthetically available radiation), as opposed to energy.

quantum yield: The number of CO_2 molecules fixed in biomass per quantum of light absorbed by a plant; it is linearly related to energy conversion efficiency.

quasi-single-scattering approximation (QSSA): An approximate analytical solution to the radiative transfer equation that accounts for only single scattering of photons under very restrictive conditions such as the assumption that forward-scattered light is treated as unscattered, the water is homogeneous, the incident light source is collimated, and the sea surface is level. Further discussion

radiance: The radiant power in a beam per unit solid angle, per unit area perpendicular to the beam, per unit wavelength interval. Radiance is the fundamental radiometric quantity from which all others can be derived. Units: [W m^{-2} sr^{-1} nm^{-1}]. Further discussion

radiative transfer equation (RTE): A linear integrodifferential equation that expresses conservation of energy in terms of the radiance. The RTE describes the rate of change with distance of the radiance in a collimated beam with a specified location, direction, and wavelength; the equation accounts for all losses (e.g., due to absorption and scattering out of the beam) and gains (e.g., by emission or scattering into the beam). Further discussion beginning at radiative transfer equations

radiometer: An instrument used to measure radiant energy (as opposed to the number of photons).

radiometry: The science of the measurement of radiant energy.

Raman scattering: Inelastic scattering in which the energy of the scattered photon equals the energy of the incident photon plus or minus energy determined by the vibrational

and rotational frequencies of the scattering molecule; characterized by a volume scattering function that has forward-backward directional symmetry. (The accent is on the first syllable, not the second.) Further discussion

Rayleigh scattering theory: A mathematical model that describes elastic scattering by very small particles (small relative to the wavelength of the light being scattered; e.g., molecules); it is characterized by a volume scattering function that depends inversely with the fourth power of the wavelength and has forward-backward directional symmetry. Often called Rayleigh scattering, although it is a mathematical model for scattering under certain conditions, not a physical scattering process. Further discussion

reflectance: Refers to any of several measures of how much light leaves a region normalized by how much light is incident onto the region; reflectances are AOPs. Units vary. Further discussion.

refraction: The change in direction of a light beam when crossing an interface between two media that have different real indices of refraction; see index of refraction. Further discussion

refractive index: See index of refraction.

remote sensing reflectance: The ratio of the "water-leaving" radiance [W m^{-2} sr^{-1} nm^{-1}] in air to the downward plane irradiance [W m^{-2} nm^{-1}] incident onto the sea surface, with both measured just above the sea surface. The remote-sensing reflectance is an AOP and is the fundamental optical quantity used in ocean color remote sensing. Units: [sr^{-1}]. Further discussion

scatterance: The fraction of the incident power at a given wavelength that is scattered within a volume. Nondimensional. Further discussion

scattering albedo: See albedo of single scattering.

scattering angle: The angle between the directions before and after scattering. Units: [degrees] or [radians] Further discussion.

scattering coefficient: The scatterance per unit distance of photon travel in a medium, i.e., the limit of the ratio of the spectral scatterance to the distance of photon travel as that distance becomes vanishingly small. Units: [m^{-1}]. Further discussion.

SeaWiFS: The Sea-viewing Wide Field-of-view Sensor satellite operational from 1998 to 2010 that measured radiance in wavelengths centered at 412, 443, 490, 510, 555, and 670 nm (all with 20 nm bandwidth) and 765 and 865 nm (both with 40 nm bandwidth). It was a follow-on to the CZCS sensor and likewise revolutionized ocean color remote sensing. Further discussion.

Secchi depth: The depth at which a Secchi disk disappears from view as it is lowered in water. The Secchi depth is an easily made measure of water clarity. Units: [m] Further discussion.

Secchi disk: A (usually) white disk of diameter 20-30 cm, used as a qualitative way of measuring water clarity by visually observing the depth as which the disk is no longer visible as it is lowered into the water. Although replaced by modern instruments for quantitative studies, Secchi depth measurements are still of interest because of the ease of measurement and the large database of historical observations going back over a century. Further discussion.

seston: The total animate and inanimate, organic and inorganic, particulate matter in natural waters.

single-scattering approximation (SSA): An approximate analytical solution to the radiative transfer equation that accounts for only single scattering of photons. It is derived under very restrictive conditions that the water is homogeneous, the incident light source is collimated, and the sea surface is level. It gives good results only if absorption strongly dominates scattering. Further discussion

Snel's law: The law that describes the refraction of light at an interface between two media that have different real indices of refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$, where n_1 and n_2 are the indices of refraction of the two media and θ_1 and θ_2 are the angles to the normal of the interface. (The correct spelling is Snel, not Snell, which is an Anglicization of the Latinization Snellius of the Dutch Snel; his full name is Willebrord Snel van Royen.) Further discussion

source functions: The terms in the radiative transfer equation that describe the inelastic scattering and true emission contributions to a beam of radiation. Further discussion

specific: The adjective used to express a quantity per unit mass or unit concentration.

specific absorption coefficient: The absorption coefficient [m^{-1}] per unit concentration of material. For chlorophyll in concentration units of [$\mathrm{mg\,m}^{-3}$], the chlorophyll-specific absorption coefficient has units of [$\mathrm{m}^{-1}/(\mathrm{mg\,m}^{-3}) = \mathrm{m}^2/\mathrm{mg}$]. For dissolved matter measured in $\mathrm{ppm_v}$ (parts per million by volume), the specific absorption coefficient would have units of [$\mathrm{m}^{-1}/\mathrm{ppm_v}$].

specific scattering coefficient: The scattering coefficient [m^{-1}] per unit concentration of material. For chlorophyll in concentration units of [$\mathrm{mg\,m}^{-3}$], the chlorophyll-specific scattering coefficient has units of [$\mathrm{m}^{-1}/(\mathrm{mg\,m}^{-3}) = \mathrm{m}^2/\mathrm{mg}$].

spectral: Refers either to (1) the amount of radiant energy per unit wavelength interval, or (2) the wavelength dependence of a quantity. Thus spectral irradiance is the power per unit area per unit wavelength interval (usually expressed in 1/nm or $1/\mu$m). Spectral quantities are often estimated from broad-band measurements divided by the band width of the instrument. See broad-band.

spectroradiometer: A radiometer that measures radiant energy as a function of wavelength.

Stokes parameters: Four parameters used to describe polarized radiation; one component describes the radiance (or irradiance) without regard to the state of polarization, two components describe the states of linear polarization with respect to a chosen reference plane, and one component describes the state of circular polarization. The four components together comprise the Stokes vector. Further discussion beginning at radiative transfer equations

tripton: Inanimate particulate matter in natural waters.

two-flow equations: A set of two coupled differential equations for upwelling and downwelling irradiances obtained by integrating the radiative transfer equation over the hemispheres of downward and upward directions. Although once useful for approximate calculations in pre-computer days, the two-flow equations are no longer needed. In any case, the inputs needed to solve them are AOPs, not IOPs, and cannot be known accurately unless the radiance is known.

two-stream approximation: The simplification of considering just light going downward and upward, as in the two-flow equations.

visible wavelengths: Visible light, i.e., light than can be detected by the human eye, is usually considered to be wavelengths from 400 to 700 nm, but sometimes 380 to 720 nm.

volume scattering function (VSF): The ratio of the scattered intensity [W sr^{-1}] to the incident irradiance [W m^{-2}] per unit volume [m^3]. The VSF describes both the angular pattern of the light scattered from an incident direction and the magnitude (strength) of the scattering. The integral of the volume scattering function over all directions (all solid angles) is the scattering coefficient. The VSF can be written as the product of the phase function [sr^{-1}] and the scattering coefficient [m^{-1}]. Units: [m^{-1} sr^{-1}] Further discussion

zenith angle: The angle between a given direction and the upward (zenith) direction. Units: [degrees] or [radians].

zooplankton: Animal forms of plankton. Sizes range from microscopic protozoans, to small crustaceans like copepods and krill, to large jellyfish; may include egg and larval forms of larger organisms.