Captured energy is not all retained

Primary productivity measures how fast producers store captured energy in organic compounds. Topic 1.8 focuses on solar energy captured through photosynthesis.

1. SEPARATE GROSS FROM NET

$$NPP = GPP - R$$

GPP	Gross primary productivity: total rate of photosynthetic energy capture.
R	Producer respiration: rate of captured energy use in metabolism.
NPP	Net primary productivity: rate of energy storage as new organic matter after producer respiration.

2. SUBTRACT THE CORRECT RESPIRATION

R here is respiration by the producers, not by all organisms in the ecosystem. Plants respire as well as photosynthesize. GPP is the energy captured, not all sunlight that reaches the ecosystem.

3. WHY NPP MATTERS

NPP supplies new organic matter that can support growth and reproduction, grazing food webs and decomposers. It is potentially available to heterotrophs; not all of it is eaten or converted into consumer biomass.

4. RATE IS NOT STANDING BIOMASS

Biomass is an amount present at a particular time. Productivity measures production over time. Rapid growth and rapid consumption can coexist with a small standing biomass.

Definitions and area/time units: College Board, ENG-1.A.1-4.
Producer energy use and biomass turnover: OpenStax, Biology 2e 46.2.

Scope: College Board AP Environmental Science CED (2025), Topic 1.8, p. 43.

Calculate NPP and keep the units

Use GPP and producer respiration measured over the same area and time interval. The example below is invented to demonstrate the calculation, not a field measurement.

1. WORKED ENERGY BALANCE

GPP = 1,200 kcal m^{-2} yr^{-1}
R = 480 kcal m^{-2} yr^{-1}

NPP = 1,200 - 480 = **720 kcal m^{-2} yr^{-1}**



The whole bar is GPP, not incoming sunlight. Here 40% supports producer respiration and 60% remains as NPP; these are not universal percentages.

2. READ EACH PART OF THE UNIT

kcal m^{-2} yr^{-1} = kilocalories per square meter per year

Energy / area / time is a productivity rate. Without the time term, an energy-per-area value does not describe productivity.

3. REARRANGE WHEN A DIFFERENT VALUE IS MISSING

GPP = NPP + R

R = GPP - NPP

For an area of 2 square meters, this example gives 1,440 kcal of net production in one year. Multiply the per-area rate by area and duration; do not subtract consumer respiration again.

Energy accounting and units: College Board, ENG-1.A.2-4.
GPP minus producer respiration: OpenStax, Biology 2e 46.2.

Scope: College Board AP Environmental Science CED (2025), Topic 1.8, p. 43.

Light changes with water depth

Photosynthesis depends on both light intensity and usable wavelengths. Water absorbs and scatters light, so deeper water receives less light and a changed spectrum.

1. COMPARE THE LIGHT THAT REMAINS

RED LIGHT

Most red light is absorbed within the upper 1 meter of water.

BLUE LIGHT

Blue light penetrates beyond 100 meters only in the clearest water.

These syllabus reference depths are not fixed boundaries for every lake or ocean. Suspended particles and water clarity affect penetration. Detectable light at depth need not be enough for photosynthesis.

2. PIGMENTS HELP USE AVAILABLE WAVELENGTHS

Different photosynthetic pigments absorb different wavelengths. A mixture of chlorophylls and other pigments broadens the range an organism can use. Aquatic producers are adapted to the light available in their habitat; no pigment can make photosynthesis work without enough light.

3. LIGHT IS NOT THE ONLY LIMIT

Nutrient availability also affects aquatic productivity. Phytoplankton need materials such as nitrogen and phosphorus, and growth depends on temperature and other conditions. More light alone may not raise productivity when another necessary resource is scarce.

Distinguish rates (GPP and NPP) from the amount of biomass already present.

Wavelength and depth: College Board, ENG-1.A.5; NOAA, Light in the ocean.
Pigment absorption: OpenStax, Biology 2e 8.2.
Aquatic growth requirements: NASA, What are Phytoplankton?

Scope: College Board AP Environmental Science CED (2025), Topic 1.8, p. 43.