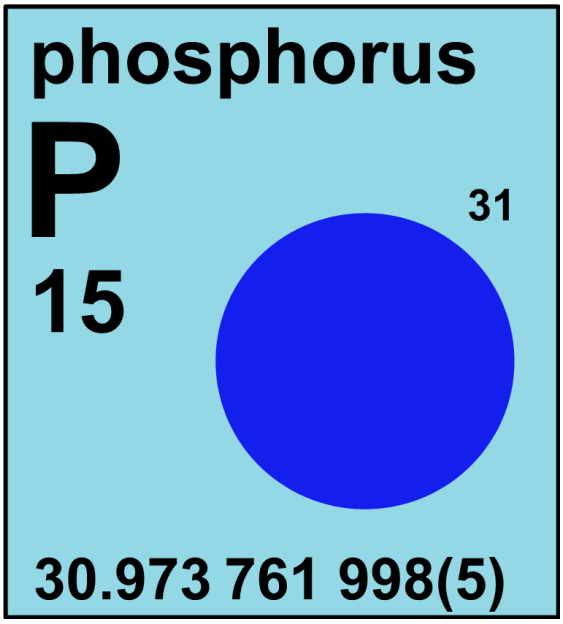
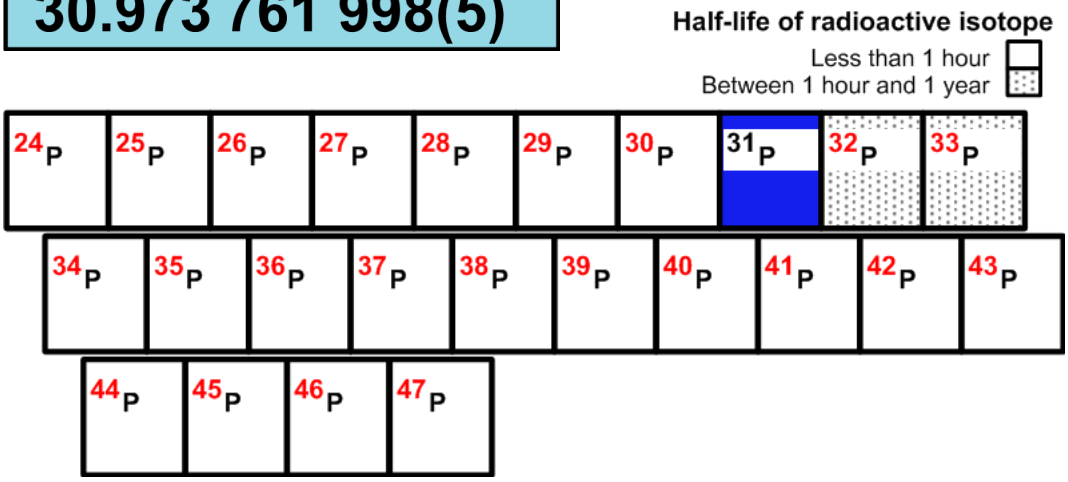
4.15 phosphorus



Stable isotope	Relative atomic mass	Mole fraction
^{31}P	30.973 761 998	1



4.15.1 Phosphorus isotopes in biology

^{32}P (**half-life** of 14.3 days) is a **radioactive isotope** of phosphorus that is used to help understand the biological and chemical processes in plants. It is chemically identical to other **isotopes** of phosphorous and can be substituted in biological and chemical reactions. For example, a phosphate solution containing ^{32}P (which has the identical behavior of non-radioactive ^{31}P) can be inserted into the roots of a plant, and its movement can then be tracked throughout the plant with the use of a **Geiger counter**. This movement detection study helps scientists to better understand how plants use phosphorous to reproduce and grow [128, 129].

At the molecular level, ^{32}P can substitute for ^{31}P in nucleotides of **DNA** or RNA (ribonucleic acid, a single stranded molecule that regulates genes). Radioactive probes can be created to help identify the presence, absence, and quantity of genes in a system [130, 131].

4.15.2 Phosphorus isotopes in Earth/planetary science

^{32}P has been used as a **tracer** to help determine phosphorus nutrient cycling in eutrophied lakes (lakes rich in organic and mineral nutrients commonly leading to the excessive growth of phytoplankton, a self-feeding water organism) (Figure 4.15.1). In one experiment, phosphoric acid labeled with ^{32}P was added to a lake that had been experimentally eutrophied. ^{32}P was measured in microphytoplankton (plankton visible only with a microscope), phytoplankton, and zooplankton (tiny animals that live suspended in fresh or salt water), and the amount of incorporated ^{32}P was determined [129].

^{33}P has been used to better understand phosphorus dynamics in the environment at the sediment-surface level. Phosphorus is a necessary nutrient for many biota (the plant and animal life of a particular habitat, region, or geological period). Understanding bioavailability and sorption (bonding) of this nutrient to particles in soil is important for understanding ecosystem health. Organic and inorganic phosphorus **substrates isotopically labeled** with ^{33}P can be tracked within a sediment system to determine their transport properties and availability to biota [132].

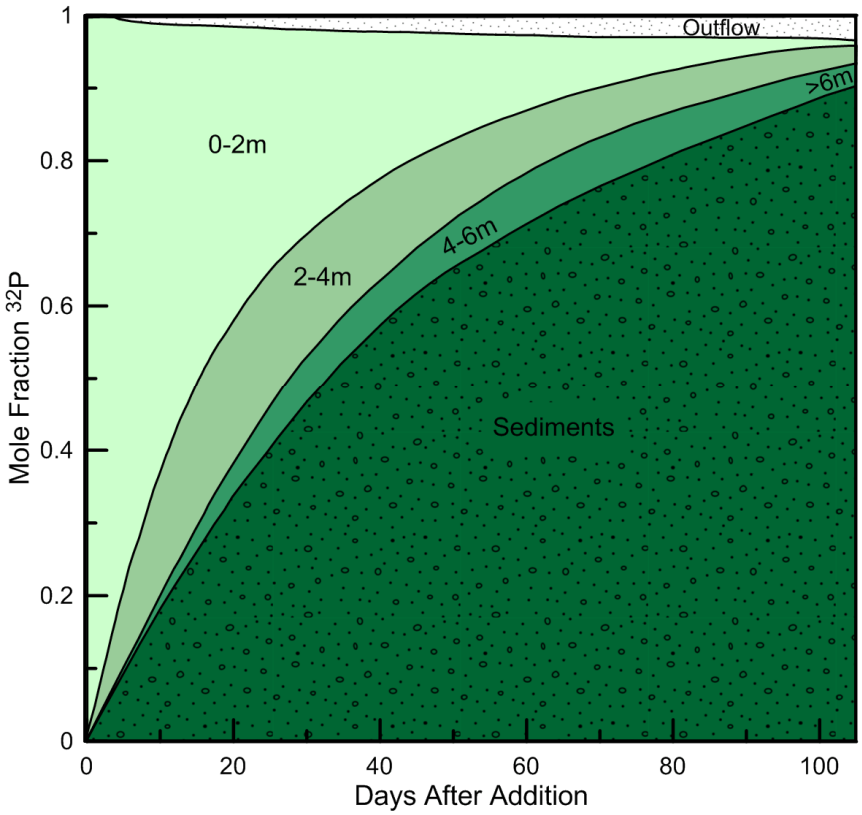


Fig. 4.15.1: Partitioning of ^{32}P among water layers, the sediments, and outflow during the 105 days following addition of ^{32}P to the upper layer of stratified Lake 227 (northwestern Ontario) to trace the lake's phosphorus cycle during lake stratification and fall overturn (modified from [129]).

4.15.3 Phosphorus isotopes in industry

^{32}P was added to tires in the 1950s by Goodrich Laboratories to help determine the location and depth of tire wear in performance tests [133].

4.15.4 Phosphorus isotopes in medicine

Beta emissions from the radioactive isotope ^{32}P can be used in drug therapy of cancerous bone masses. By injecting a patient with a ^{32}P pharmaceutical, tumors and other cells can be targeted for cell death, which also helps to alleviate pain[134, 135]. For example, *Polycythemia vera* is the condition of having excess red blood cells in the bone marrow, and ^{32}P can be used to treat this condition by reducing the number of red blood cells. However, there is no cure for this condition [136]. Using a ^{32}P labeled bio-silicone product, ^{32}P has been used as the radioactive target in **brachytherapy** of solid tumors in the lung [137]. Depending on the type of ^{32}P-labeled compound (antibody or pharmaceutical drug), when ingested or injected into the body, specific body parts (blood, tumors, joints, or bones) can be targeted for visualization and imaged using a **gamma camera**. This is useful for imaging cancer sites and for treatment monitoring of oncologic patients [130, 131, 135].