FIKSASI NITROGEN

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TABLE 12.1
The major processes of the biogeochemical nitrogen cycle

Process	Definition	Rate (10^{12} g yr^{-1})[a]
Industrial fixation	Industrial conversion of molecular nitrogen to ammonia	80
Atmospheric fixation	Lightning and photochemical conversion of molecular nitrogen to nitrate	19
Biological fixation	Prokaryotic conversion of molecular nitrogen to ammonia	170
Plant acquisition	Plant absorption and assimilation of ammonium or nitrate	1200
Immobilization	Microbial absorption and assimilation of ammonium or nitrate	N/C
Ammonification	Bacterial and fungal catabolism of soil organic matter to ammonium	N/C
Nitrification	Bacterial (*Nitrosomonas* sp.) oxidation of ammonium to nitrite and subsequent bacterial (*Nitrobacter* sp.) oxidation of nitrite to nitrate	N/C
Mineralization	Bacterial and fungal catabolism of soil organic matter to mineral nitrogen through ammonification or nitrification	N/C
Volatilization	Physical loss of gaseous ammonia to the atmosphere	100
Ammonium fixation	Physical embedding of ammonium into soil particles	10
Denitrification	Bacterial conversion of nitrate to nitrous oxide and molecular nitrogen	210
Nitrate leaching	Physical flow of nitrate dissolved in groundwater out of the topsoil and eventually into the oceans	36

Note: Terrestrial organisms, the soil, and the oceans contain about 5.2×10^{15} g, 95×10^{15} g, and 6.5×10^{15} g, respectively, of organic nitrogen that is active in the cycle. Assuming that the amount of atmospheric N_2 remains constant (inputs = outputs), the *mean residence time* (the average time that a nitrogen molecule remains in organic forms) is about 370 years [(pool size)/(fixation input) = $(5.2 \times 10^{15}$ g $+ 95 \times 10^{15}$ g$)/(80 \times 10^{12}$ g $yr^{-1} + 19 \times 10^{12}$ g $yr^{-1} + 170 \times 10^{12}$ g $yr^{-1})$] (Schlesinger 1997).

[a]N/C, not calculated.

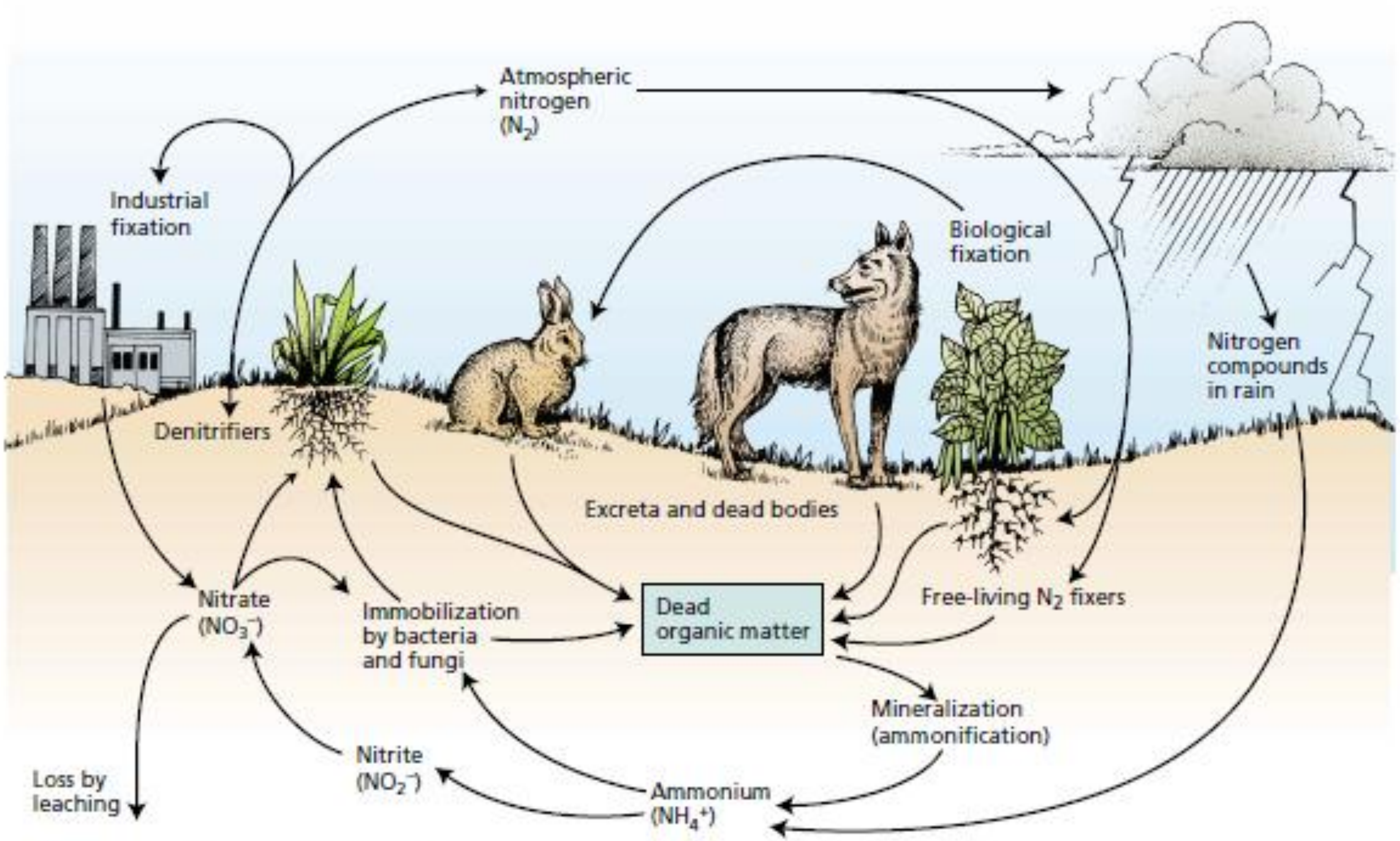


FIGURE 12.1 Nitrogen cycles through the atmosphere as it changes from a gaseous form to reduced ions before being incorporated into organic compounds in living organisms. Some of the steps involved in the nitrogen cycle are shown.

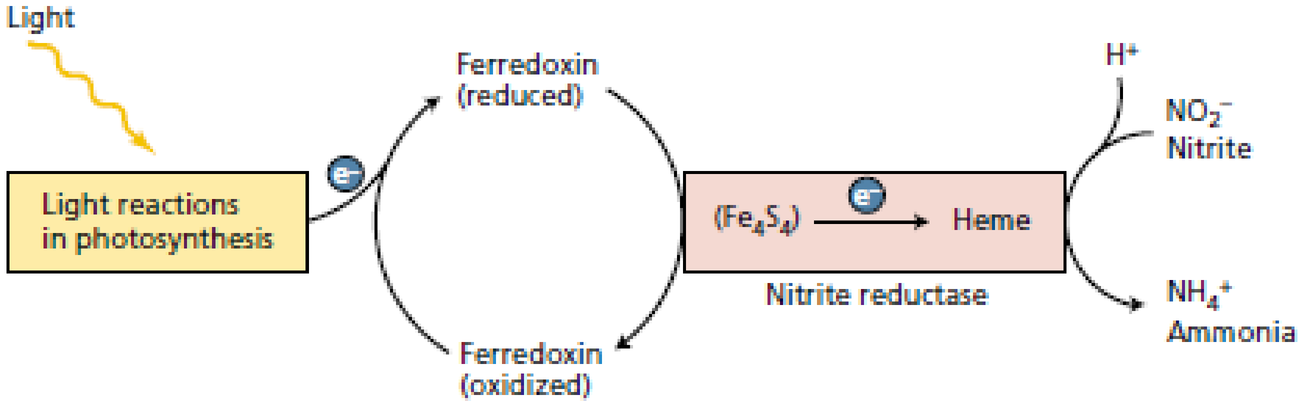


FIGURE 12.5 Model for coupling of photosynthetic electron flow, via ferredoxin, to the reduction of nitrite by nitrite reductase. The enzyme contains two prosthetic groups, Fe_4S_4 and heme, which participate in the reduction of nitrite to ammonium.

- Proses reduksi N2 menjadi ion NH4 oleh mikroorganisme prokariot
- Beberapa bakteri tanah pemfiksasi N2, ex: cyanobacteria (blue-green algae)
- Bakteri atau mikroba berasosiasi dg akar (tanaman legum)

Peran asosiasi mikroba dg tan. legum

- Aktivitasnya menguntungkan akar di sekitar tan. tsb
- Penting bg keberlangsungan rantai makanan
- Selain tan. Legum ada juga non legum yg mampu memfiksasi N2 (pohon dan berry)

TABLE 12.2
Examples of organisms that can carry out nitrogen fixation

Symbiotic nitrogen fixation	
Host plant	**N-fixing symbionts**
Leguminous: legumes, *Parasponia*	*Azorhizobium*, *Bradyrhizobium*, *Photorhizobium*, *Rhizobium*, *Sinorhizobium*
Actinorhizal: alder (tree), *Ceanothus* (shrub), *Casuarina* (tree), *Datisca* (shrub)	*Frankia*
Gunnera	*Nostoc*
Azolla (water fern)	*Anabaena*
Sugarcane	*Acetobacter*

Free-living nitrogen fixation	
Type	**N-fixing genera**
Cyanobacteria (blue-green algae)	*Anabaena*, *Calothrix*, *Nostoc*
Other bacteria	
Aerobic	*Azospirillum*, *Azotobacter*, *Beijerinckia*, *Derxia*
Facultative	*Bacillus*, *Klebsiella*
Anaerobic	
Nonphotosynthetic	*Clostridium*, *Methanococcus* (archaebacterium)
Photosynthetic	*Chromatium*, *Rhodospirillum*

TABLE 12.3
Associations between host plants and rhizobia

Plant host	Rhizobial symbiont
Parasponia (a nonlegume, formerly called *Trema*)	*Bradyrhizobium* spp.
Soybean (*Glycine max*)	*Bradyrhizobium japonicum* (slow-growing type); *Sinorhizobium fredii* (fast-growing type)
Alfalfa (*Medicago sativa*)	*Sinorhizobium meliloti*
Sesbania (aquatic)	*Azorhizobium* (forms both root and stem nodules; the stems have adventitious roots)
Bean (*Phaseolus*)	*Rhizobium leguminosarum* bv. *phaseoli*; *Rhizobium tropicii*; *Rhizobium etli*
Clover (*Trifolium*)	*Rhizobium leguminosarum* bv. *trifolii*
Pea (*Pisum sativum*)	*Rhizobium leguminosarum* bv. *viciae*
Aeschenomene (aquatic)	*Photorhizobium* (photosynthetically active rhizobia that form stem nodules, probably associated with adventitious roots)

FIGURE 12.8 Root nodules on soybean. The nodules are a result of infection by *Rhizobium japonicum*. (© Wally Eberhart/Visuals Unlimited.)

- Nitrogen diserap dalam bentuk ion NO3 dan NH4
- NH4 meningkat :aktivitas industri, vulkanik, kebakaran hutan
- NO3 meningkat :oksidasi N2 oleh O2 atau O3 (adanya radiasi UV atau cahaya)

- Pada suhu rendah :dp terjadi proses ammonifikasi
- Pada suhu hangat (pH tanah cend normal): ion NH4 dioksidasi menjadi ion Nitrit dan nitrat ....nitrifikasi

Siklus Nitrogen

- Tahapan proses konversi gas nitrogen menjadi komponen organik dan kembali ke alam dalam bentuk gas nitrogen

Ada 4 tahap

- Fiksasi nitrogen
- Ammonifikasi
- Nitrifikasi
- denitrifikasi

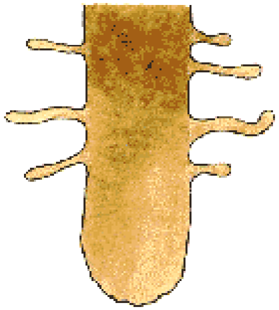
- Nitrosomonas : bakteri pengoksidasi ammonia mjd nitrit
- Nitrobacter : mereduksi nitrit menjadi nitrat
- Pada kond dingin (tanah asam): bakteri nitrifikasi kurang efektif shg ion NH4 mjd lbh penting sbg sumber N drpd NO3
- Berkaitan dg muatan positif lbh mudah diikat oleh koloid tanah pd pH rendah

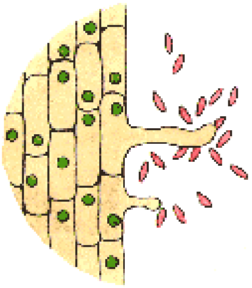
- Berkurangnya NO_3 akibat proses denitrifikasi oleh bakteri anaerob (pembntkn nitrit)

Mekanisme infeksi

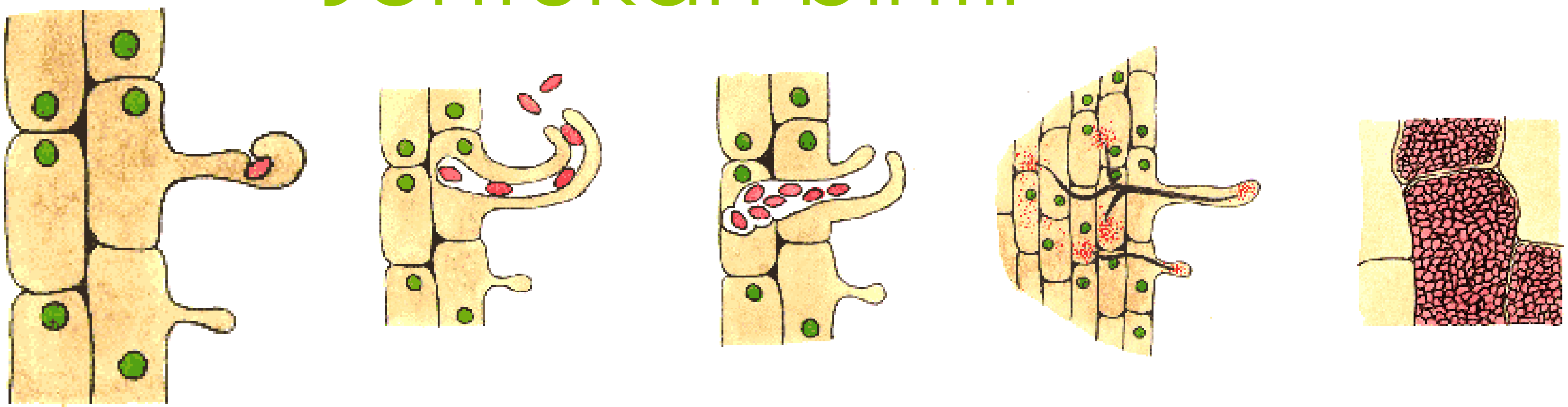
- Curling
- Alfalfa :flavonoid
- Bakteroid
- Membran peribakteroid
- leghemoglobin

Mekanisme pembentukan bintil





Pembentukan bintil



leghemoglobin

- Memberi warna merah pada bintil akar
- Berfungsi mengatur atau mengontrol oksigen dalam bintil

Observasi terhadap bintil

- Warna pink : bintil akar aktif memfiksasi nitrogen
- Warna merah : bintil lebih aktif memfiksasi Nitrogen
- Warna hijau : kemampuan memfiksasi nitrogen timadak la
- Warna abu-abu : bintil masih muda dan belum mampu memfiksasi nitrogen

Nitrogenase

- Enzim yang berperan mengkatalisis konversi gas nitrogen menjadi ammonia dalam bakteri
- Pada legum terjadi dalam bakteroid
- Sangat sensitif terhadap keberadaan oksigen