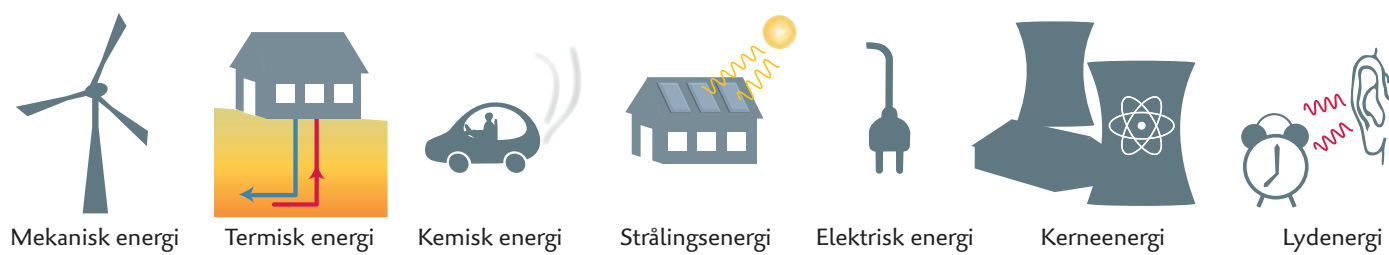


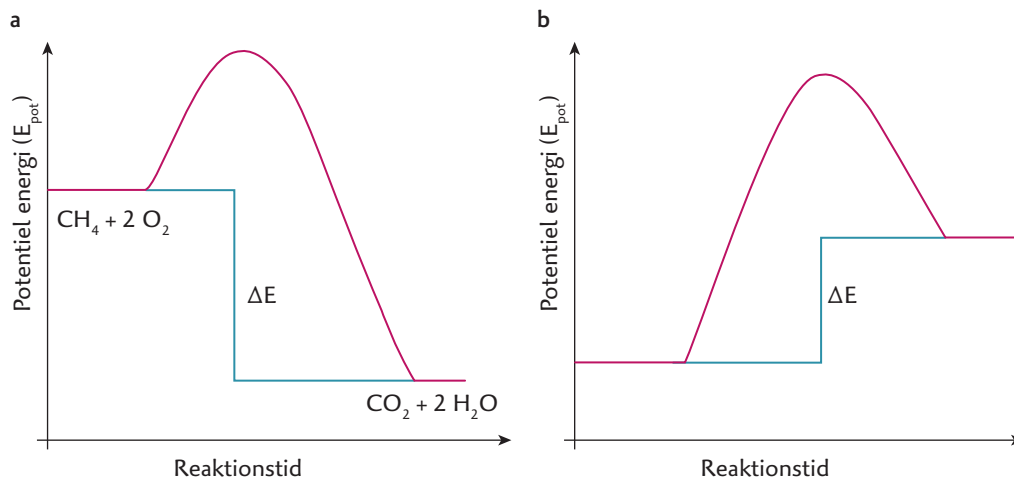
Figur 2. Forskellige typer af energi.
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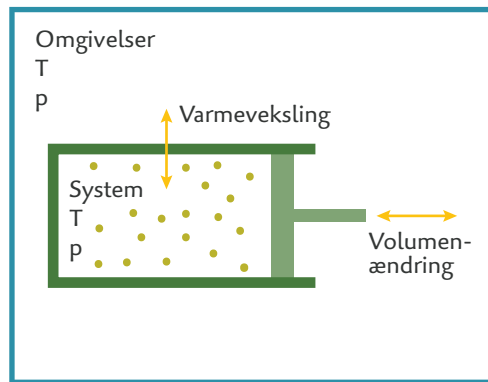
Figur 3. De syv energiformer.

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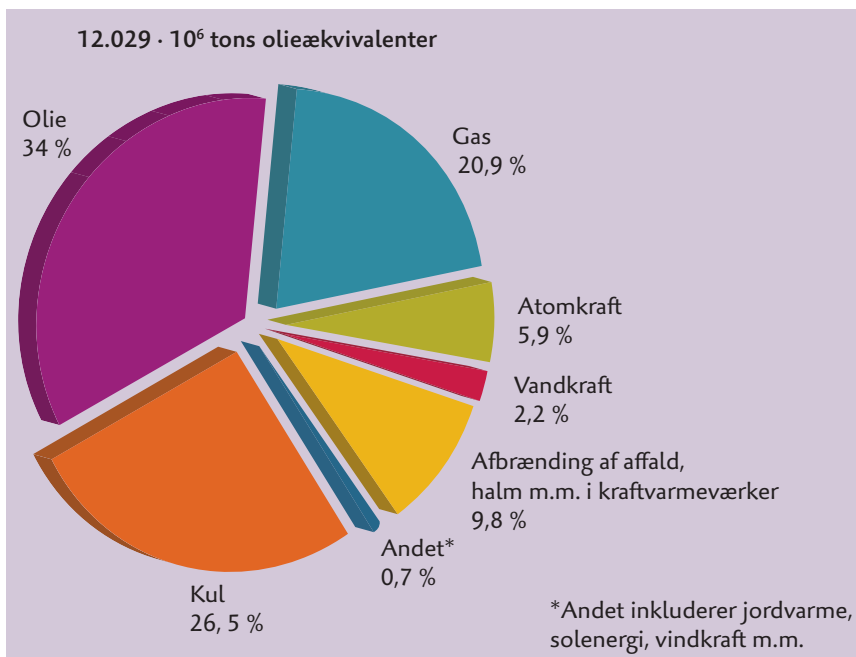
Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.



Figur 4. Exoterm og endoterm reaktion.
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Figur 5. Totalsystem.
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Figur 6. Verdens energiforbrug 2007.

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Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.

Energikilde	For at fremstille 1 kWh skal der anvendes (ca.):
Benzin	84 g
Flaskegas	78 g
Fyringsolie	86 g
Halm	280 g
Hydrogen	30 g
Kul	124 g
Naturgas (Nordsøen)	74 g
Råolie	86 g
Svær fuelolie	88 g
Træ	260 g
Træflis	180 g
Uran 235	$0,5 \cdot 10^{-4}$ g

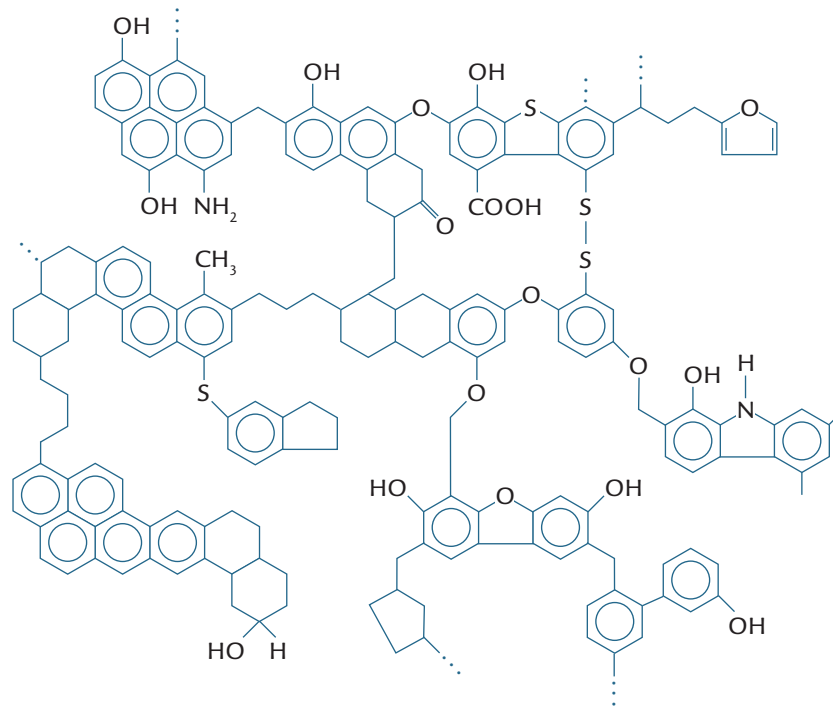
Figur 7. Energiindhold i forskellige energikilder.
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	Indhold af C i %	Indhold af H i %	Indhold af O i %
Træ	50	6	44
Tørv	55	6	39
Brunkul	73	5	22
Stenkul	84	5	10
Antracit (hårdt stenkul)	95	3	2
Diamant	100	0	0

Figur 9. Carbonrækken.

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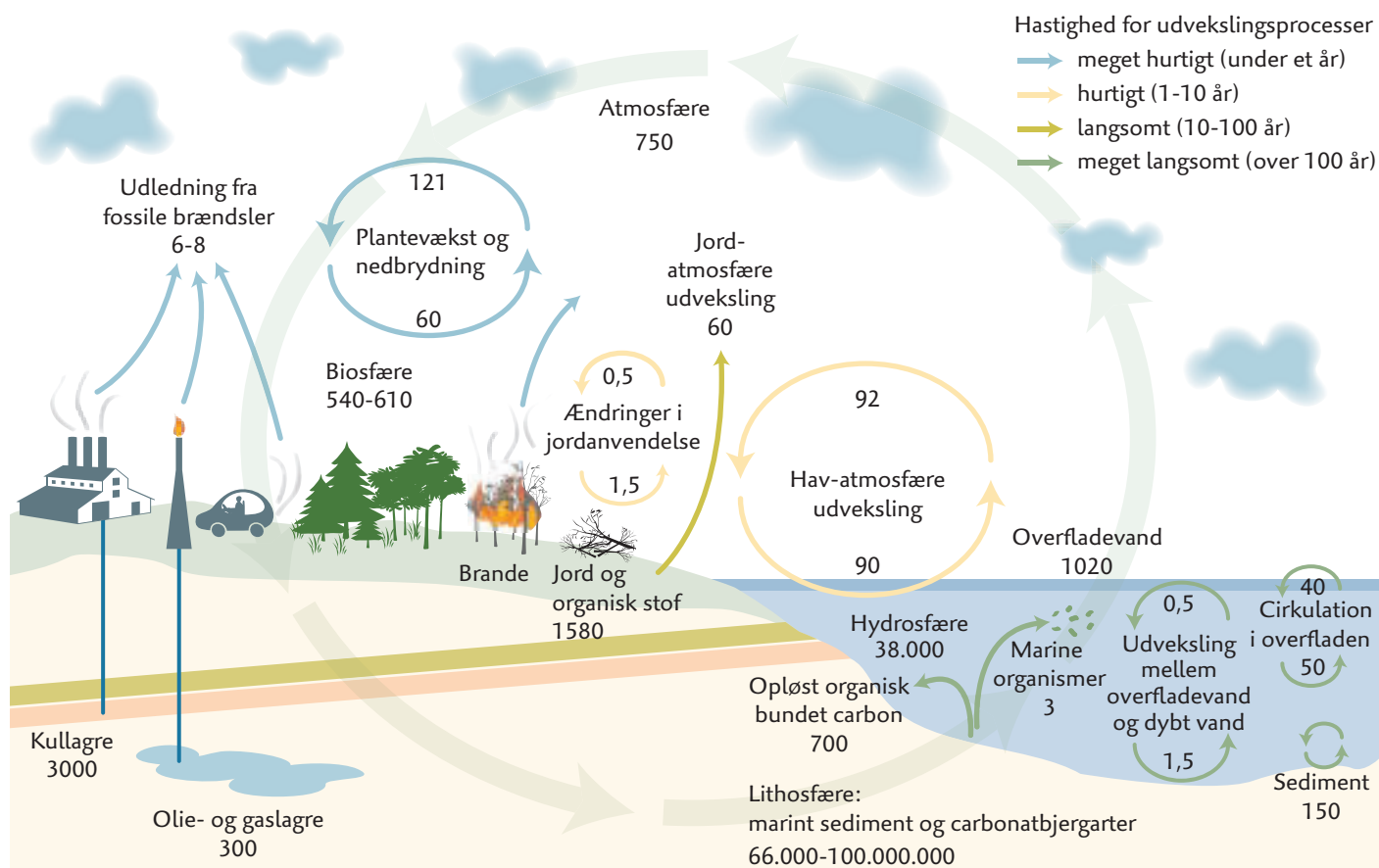
Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.



Figur 10. Kemisk opbygning af kul.
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Brændstof	Brændværdi i MJ · kg ⁻¹
Brunkul	< 24
Stenkul	25-36
Antracit	> 36
Olie	Ca. 42
Naturgas	48

Figur 11. Brændværdi af forskellige brændstoffer.
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Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.



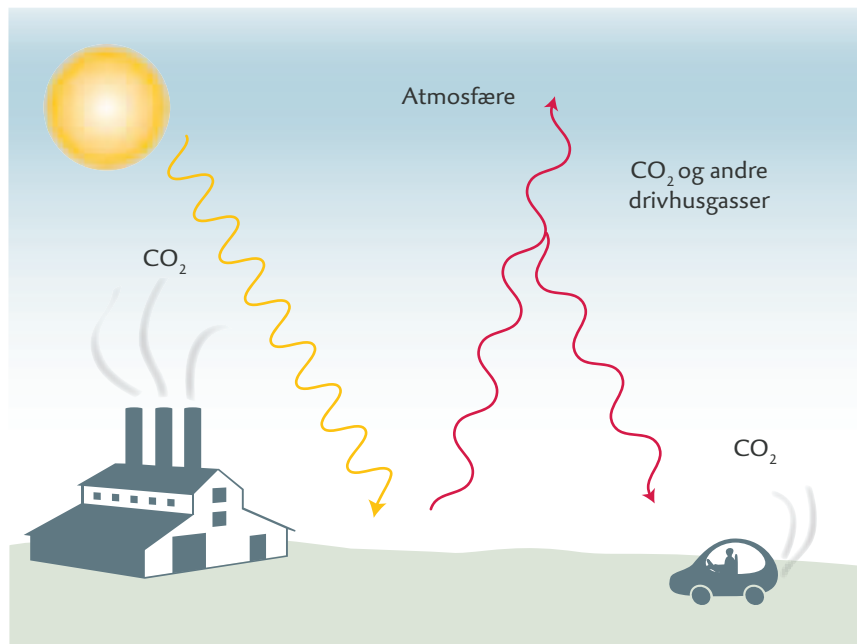
Figur 12. Carbons kredsløb.
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 Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.

Fotosyntese:	$6 \text{ CO}_2 + 12 \text{ H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2 + 6 \text{ H}_2\text{O}$ Carbondioxid og vand omdannes vha. lysenergi til glucose, oxygen og vand
Respiration:	$\text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2 + 30 (\text{ADP} + \text{P}_i) \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + 30 \text{ ATP}$ Glucose omdannes aerobt til carbondioxid og vand samt meget energi
Fermentering:	$\text{C}_6\text{H}_{12}\text{O}_6 + 2 (\text{ADP} + \text{P}_i) \rightarrow 2 \text{ CH}_3\text{CH}_2\text{OH} + 2 \text{ CO}_2 + 2 \text{ ATP}$ $\text{C}_6\text{H}_{12}\text{O}_6 + 2 (\text{ADP} + \text{P}_i) \rightarrow 2 \text{ CH}_3\text{CHOHCOOH} + 2 \text{ ATP}$ $\text{C}_6\text{H}_{12}\text{O}_6 + 2 (\text{ADP} + \text{P}_i) \rightarrow \text{C}_3\text{H}_7\text{COOH} + 2 \text{ CO}_2 + 2 \text{ H}_2 + 2 \text{ ATP}$ Glucose omdannes anaerobt til henholdsvis ethanol, 2-hydroxypropansyre (mælkesyre) eller butansyre, samt lidt energi og rester i form af carbondioxid og hydrogen

Figur 13. Fotosyntese, respiration og gæring.
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Økosystem	Biomasse ($\text{kg} \cdot \text{m}^{-2}$)	Nettoprimærproduktion ($\text{g} \text{ tørstof} \cdot \text{m}^{-2} \cdot \text{år}^{-1}$)
Tropisk regnskov	45	2200
Tempereret løvfældende skov	30	1200
Nordlig nåleskov	20	800
Tempereret græsområde	1,6	600
Kornmarker	1	650

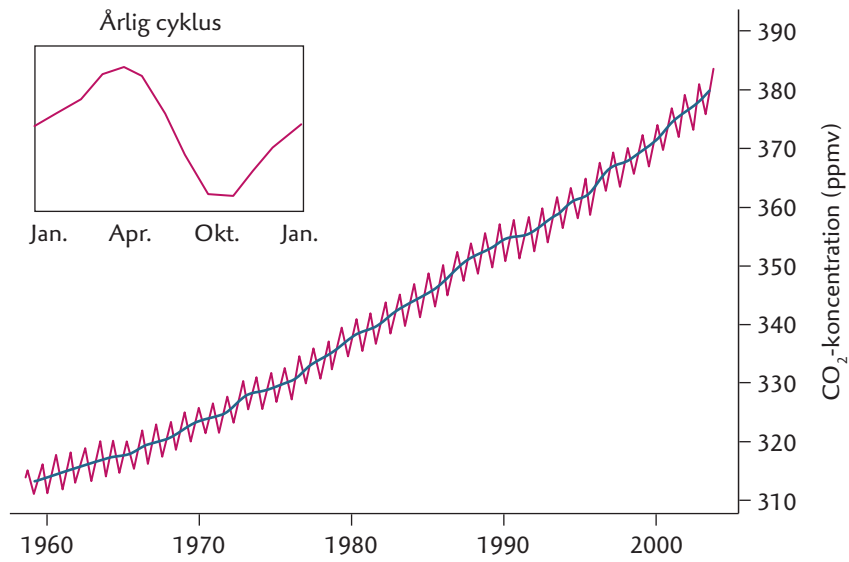
Figur 14. Økosystemers biomasse og nettoprimærproduktion.
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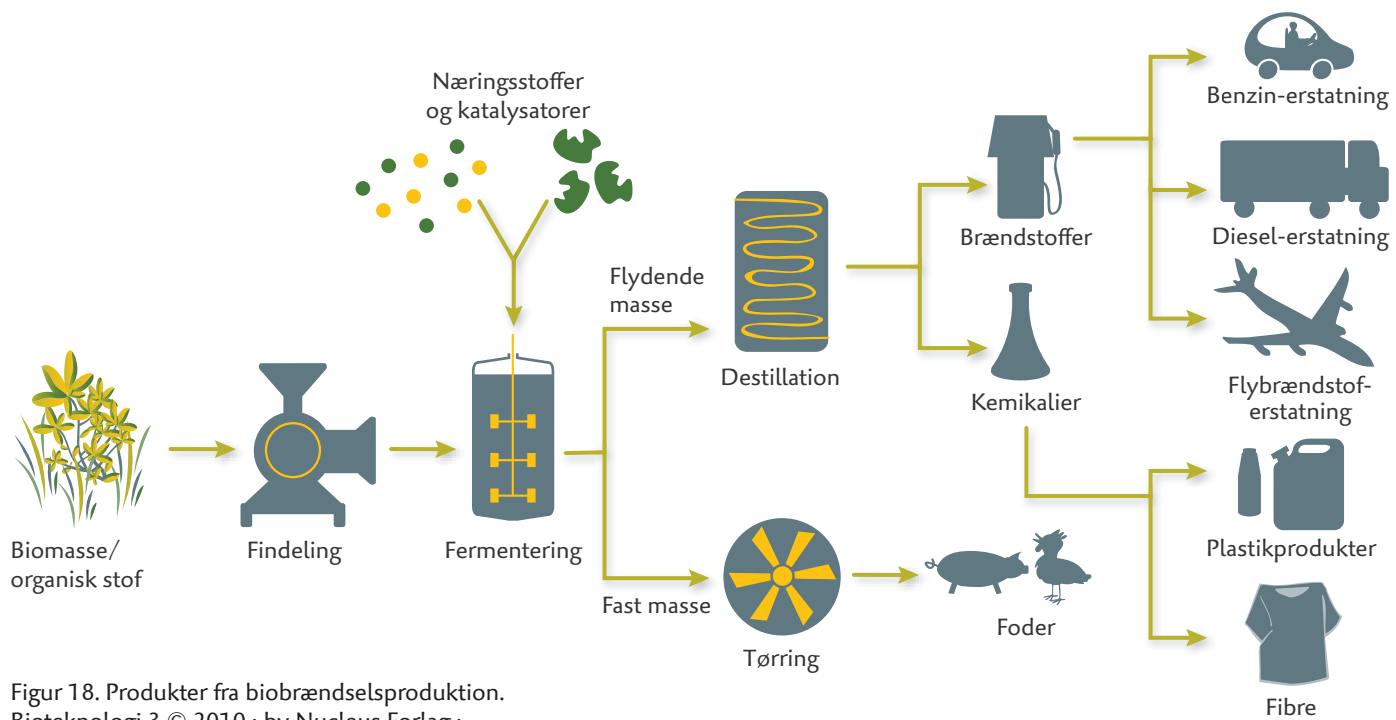
Figur 15. Drivhuseffekt.
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Drivhusgas	Naturlig forekomst	Menneskeskabt stigning	Globalt opvarmnings- potentiale på 20 år	Globalt opvarmnings- potentiale på 100 år
Carbondioxid (CO ₂)	+	+	1	1
Methan (CH ₄)	+	+	72	25
Dinitrogenoxid (N ₂ O)	+	+	289	298
Hydrofluorcarboner (HFC)		+	2330-12.000	675-14.800
Perfluorcarboner (PFC)		+	5200-8600	7300-12.200
Svovlhexafluorid (SF ₆)		+	16.300	22.800

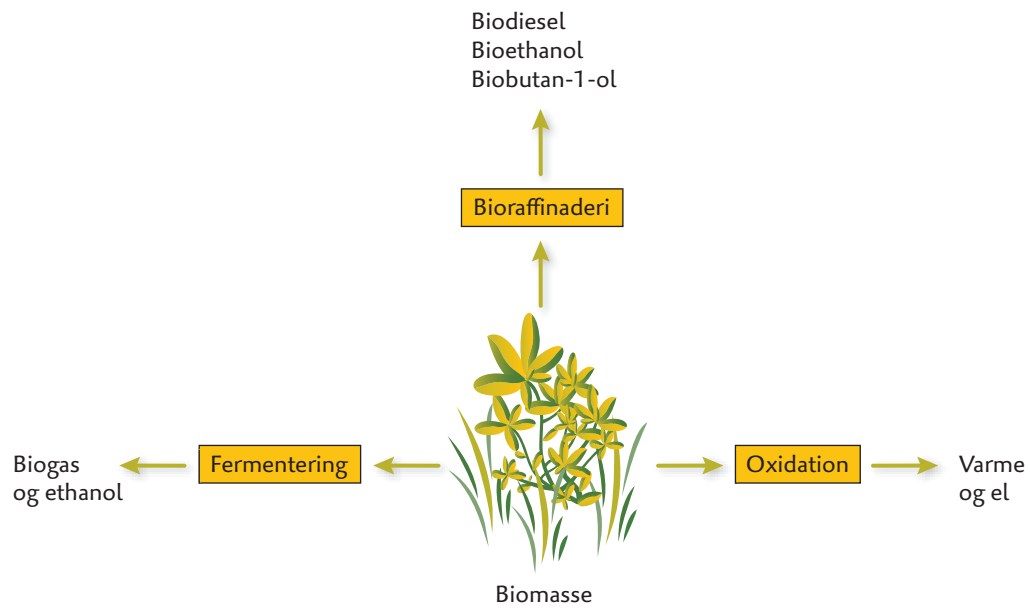
Figur 16. Drivhusgasser og deres opvarmningspotentiale.
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Figur 17. Stigning i atmosfærens carbondioxid.
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Figur 18. Produkter fra biobrændselsproduktion.
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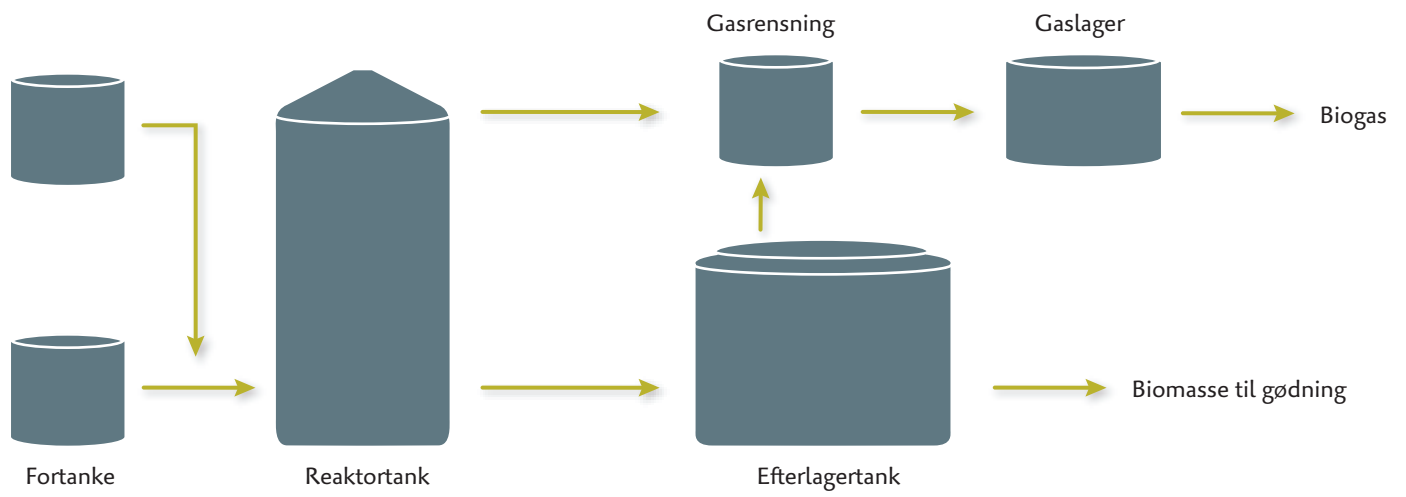
Figur 19. Udnyttelse af biomasse.
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1 ton våd biomasse i form af	Kan omdannes til så mange m ³ biogas	Hvilket svarer til så mange liter fyringsolie
Kvæggylle	22	14
Svinegylle	22	14
Gødning fra fjerkræ	50-100	33-65
Slagteriaffald, mave-tarmaffald	40-60	26-39
Fedtholdigt slagteriaffald	> 100	> 65
Fiskeolieaffald	100-1000	65-650

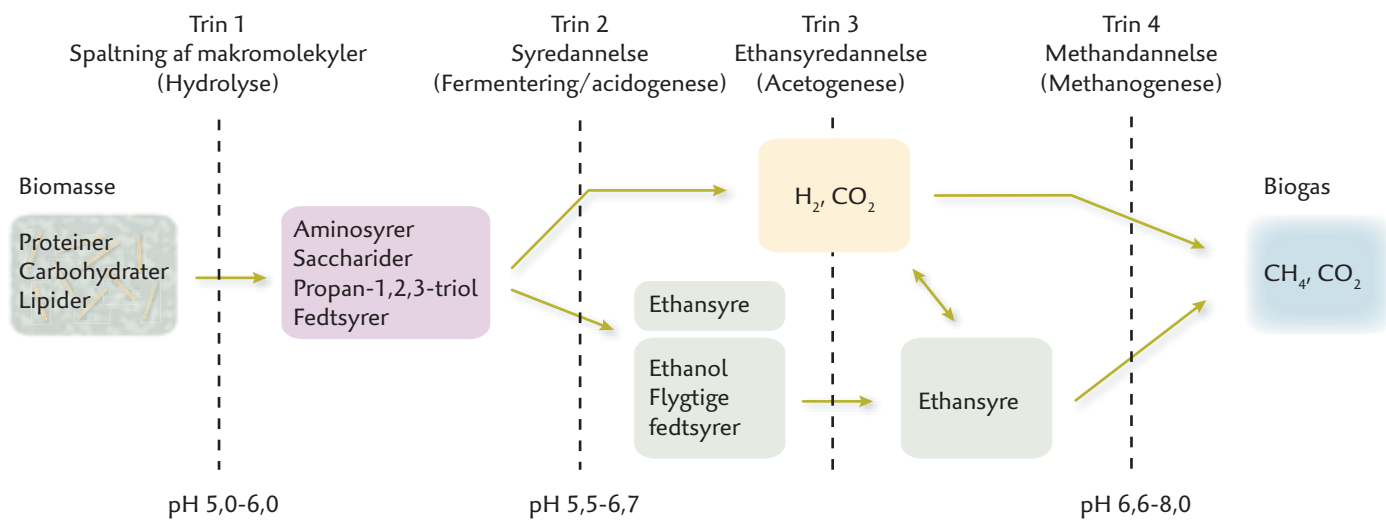
Figur 20. Typer af biomasse der kan omsættes til biogas.

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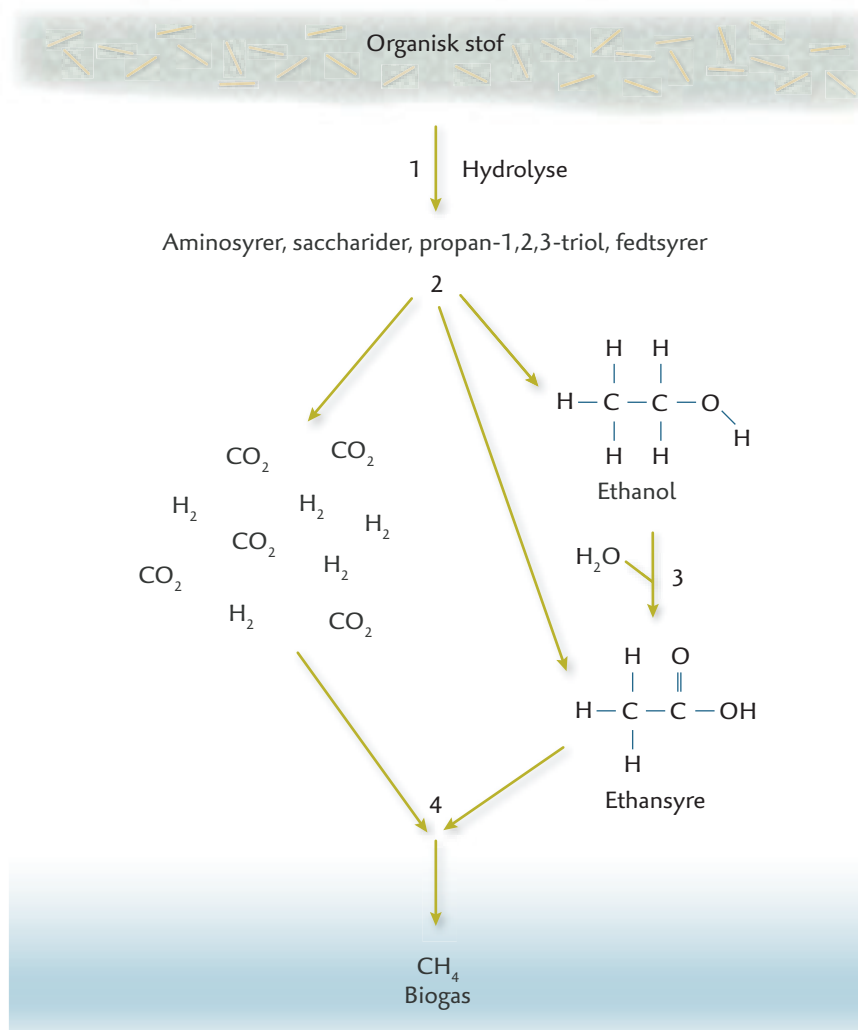
Figur 21. Opbygning af et biogasanlæg.
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Figur 22. De fire trin i biogasfremstillingen.

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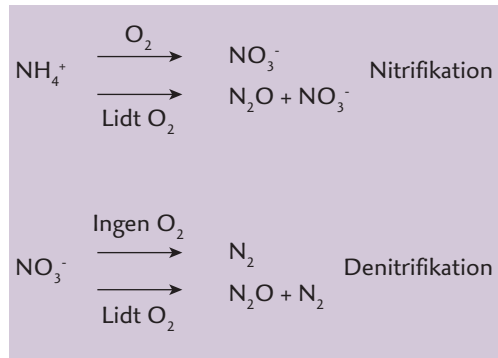
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Figur 23. Biogasproduktion.
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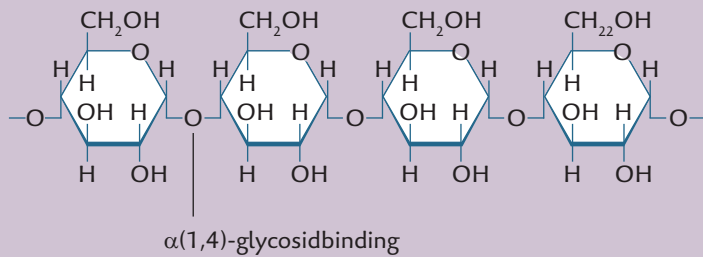
Bestanddel	Biogas m ³ /kg VS	CH ₄ -indhold %	CO ₂ -indhold %
Proteiner	0,700	71	29
Lipider	1,250	68	32
Carbohydrater	0,790	50	50

Figur 24. Biogasudbytte og -sammensætning.
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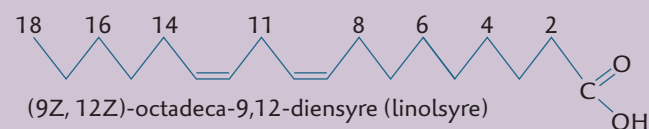
Figur 25. Nettoresultat af kvælstofomsætning.
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Kemisk opbygning af stivelse, amylose:

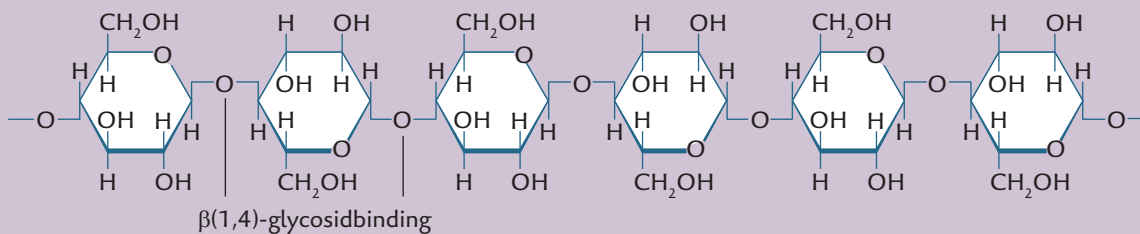


Rapsolie er opbygget af triglycerider, hvor ca. 7 % af fedtsyrekæderne er mættede, 58 % er monoumættede og 35 % er polyumættede

Eksempler:



Cellulose



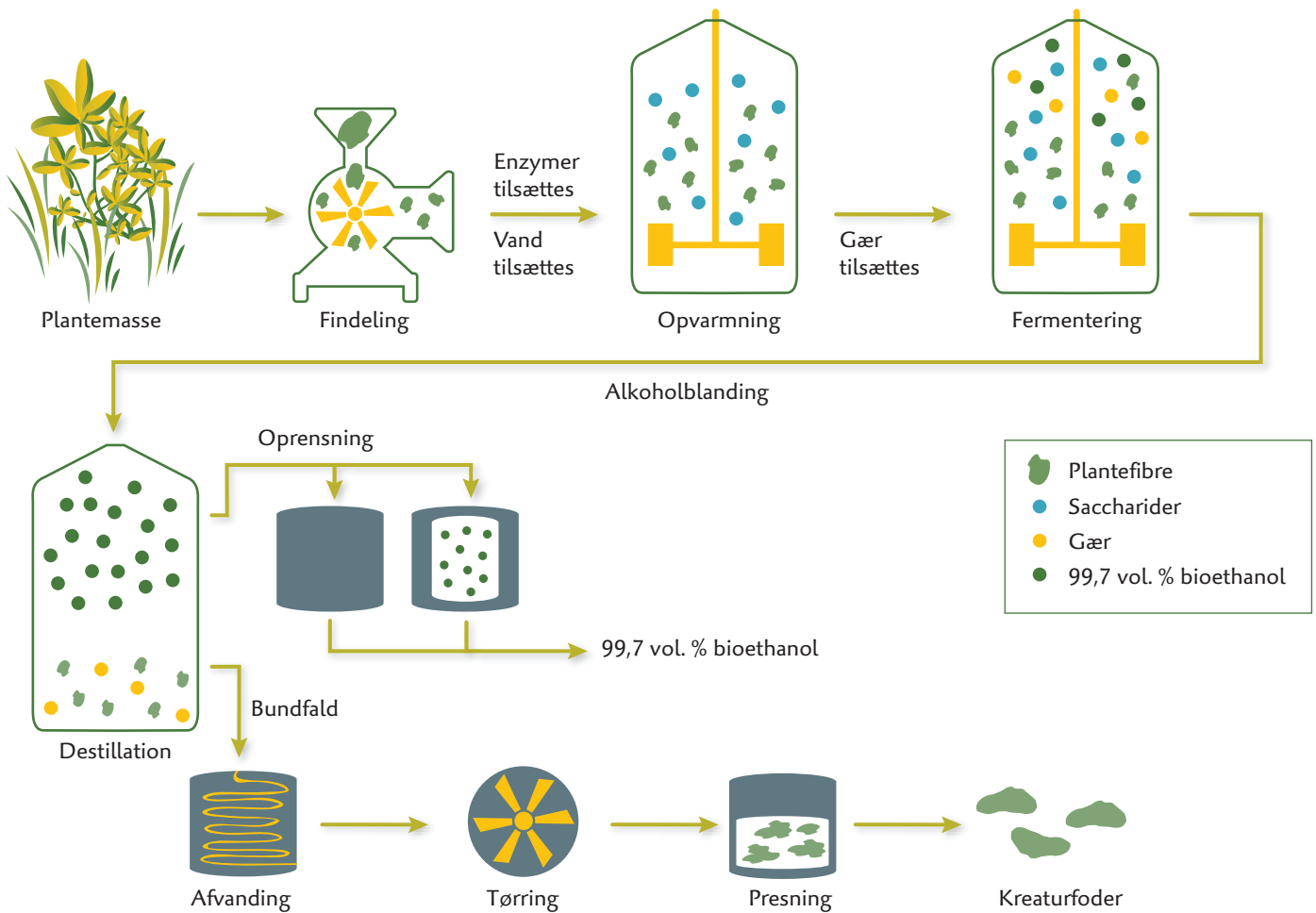
Figur 26. Indhold af amylose, rapsolie og cellulose i hvede og raps.
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Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.

Brændsel	Brændværdi MJ · kg ⁻¹
Brænde	12,0
Træbriketter	18,0
Træpiller	17,6
Halm, gul	14,4
Halm, grå	15,0
Havretræpiller	17,2
Hvede	14,5
Rug, 14 % vand	15,8

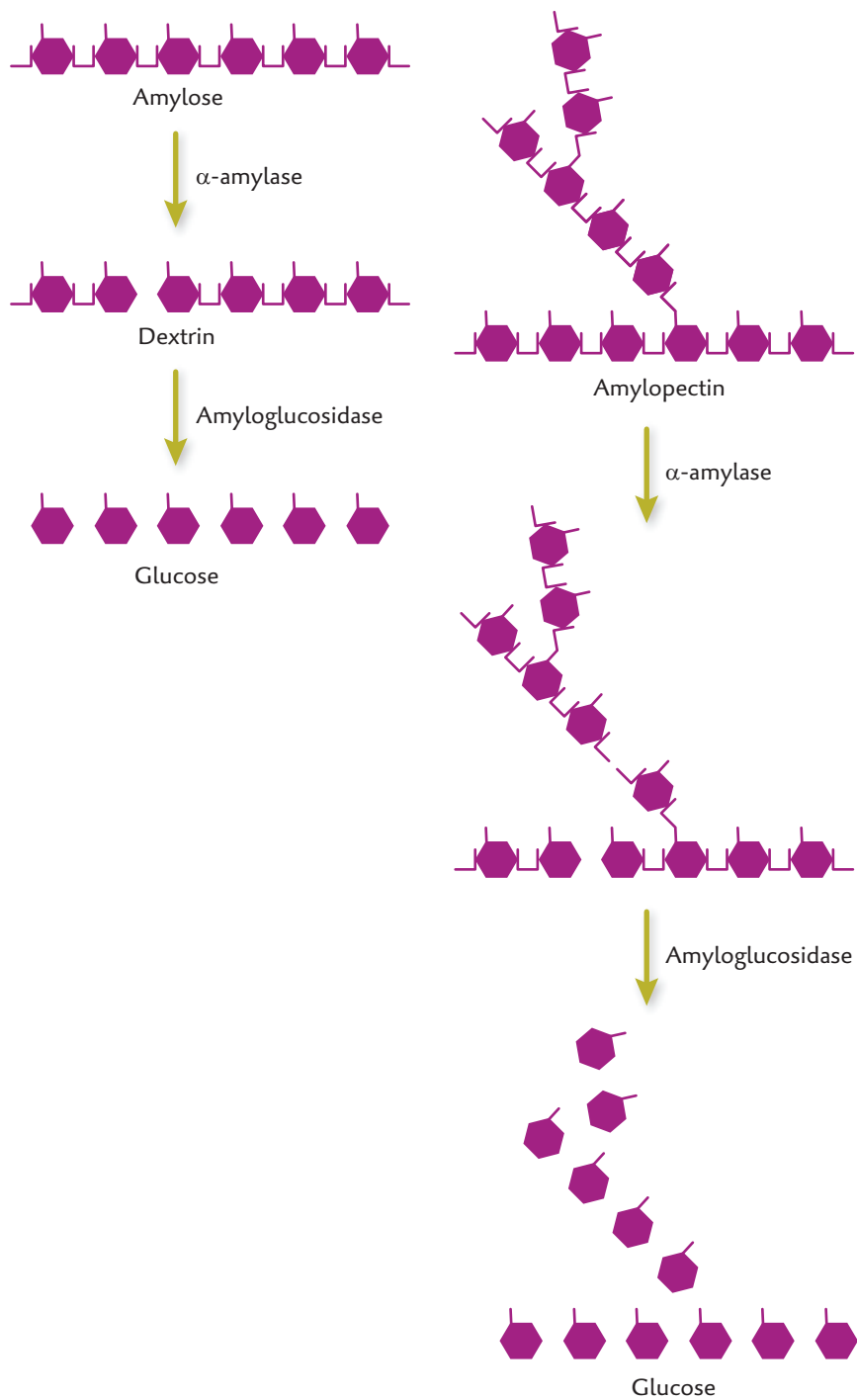
Figur 27. Plantebrændsler.

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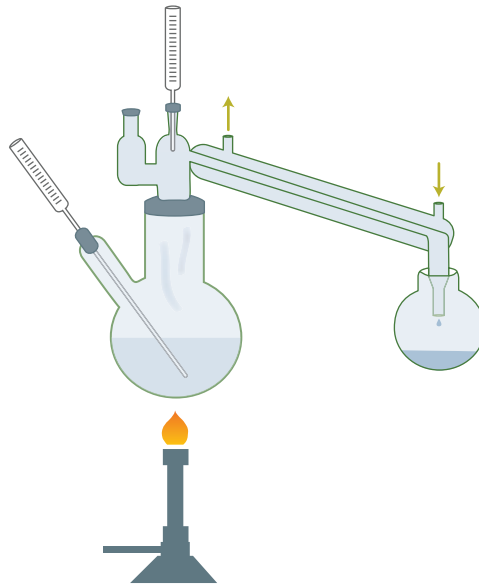
Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.



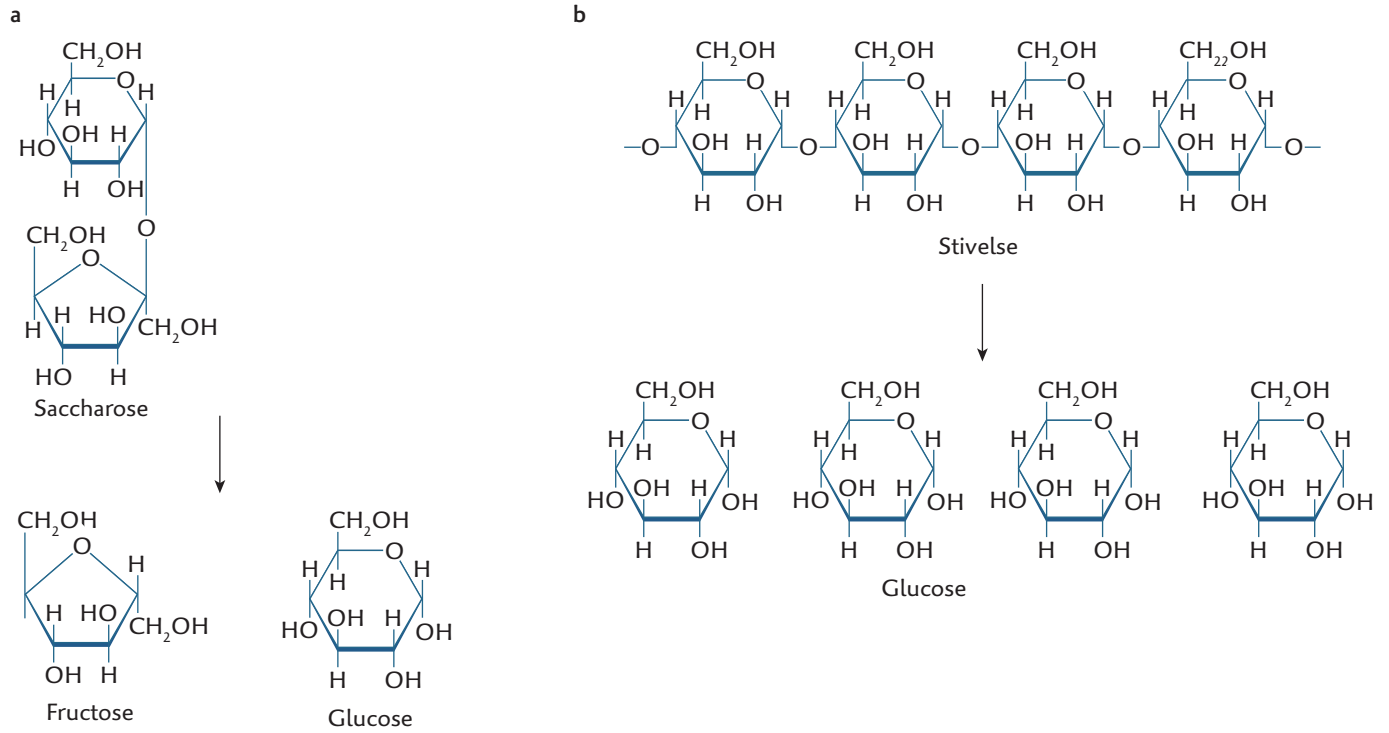
Figur 28. Fremstilling af 1. generations bioethanol.
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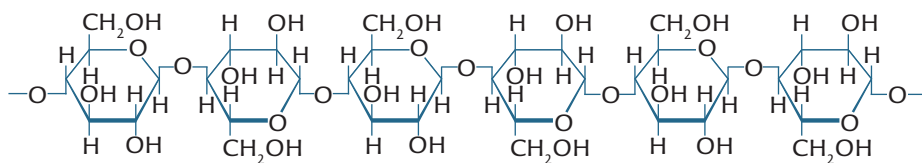
Figur 29. Enzymatisk spaltning af amylose og amylopectin.
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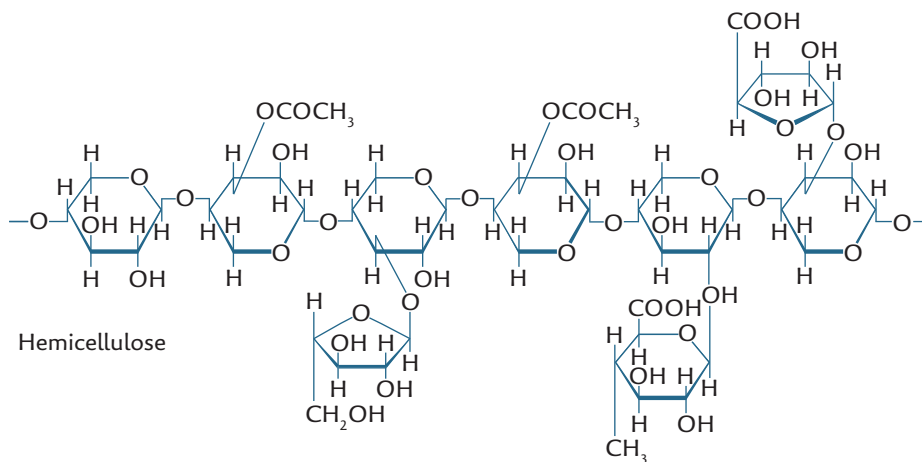
Figur 30. Destillationsapparat.
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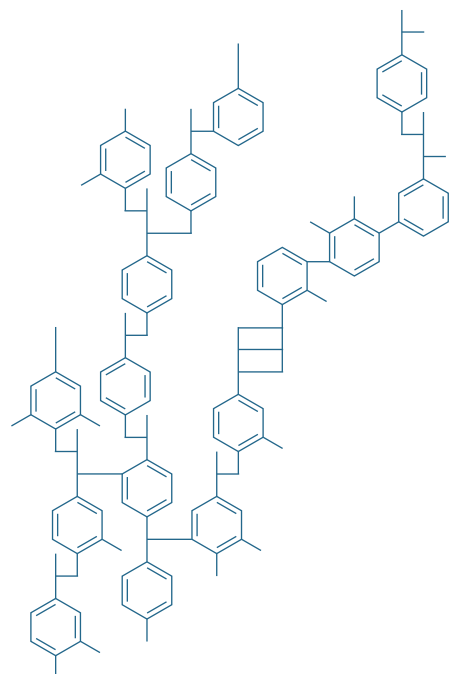
Figur 32. Carbohydratspaltning ved produktion af 1. generations bioethanol.
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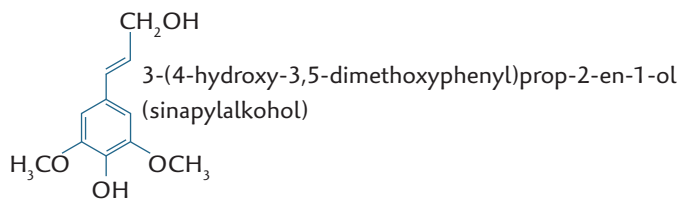
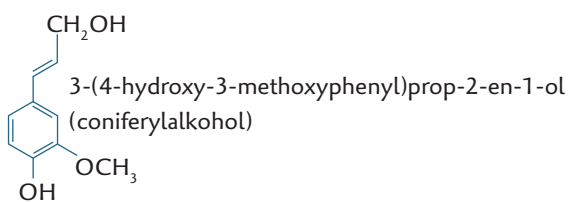
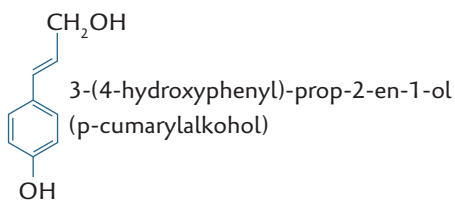
Cellulose



Hemicellulose



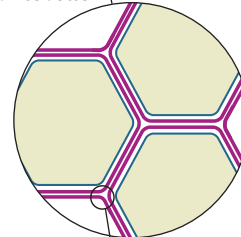
Lignin



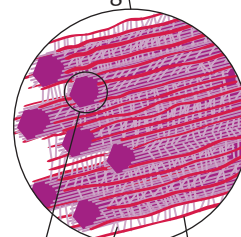
Plantebiomasse



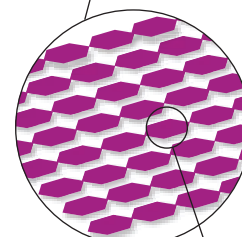
Planteceller



Plantecellevæg



Lignin
Hemicellulose

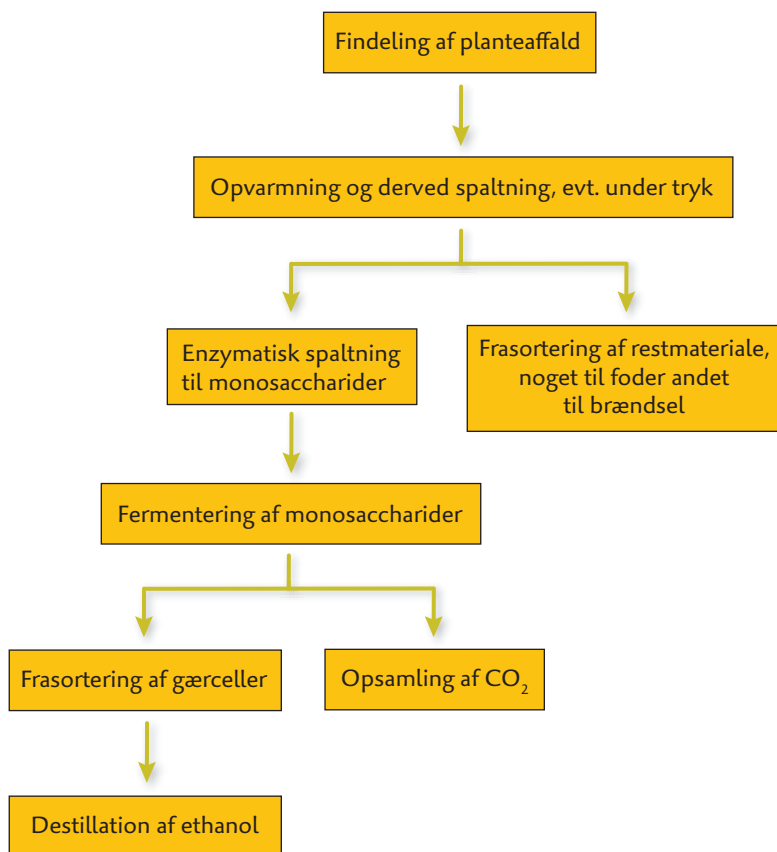


Cellulosefiber

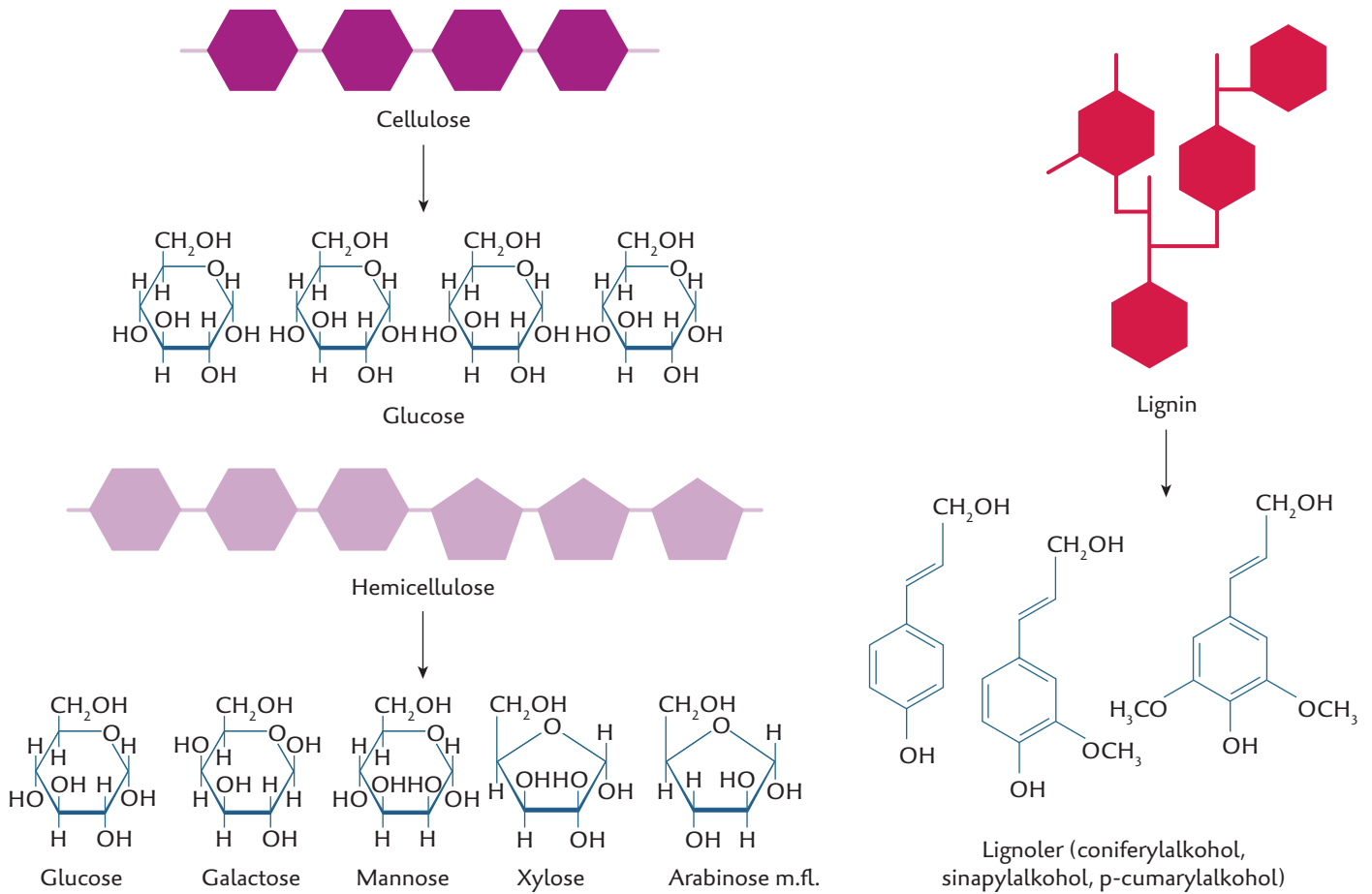


Glucose

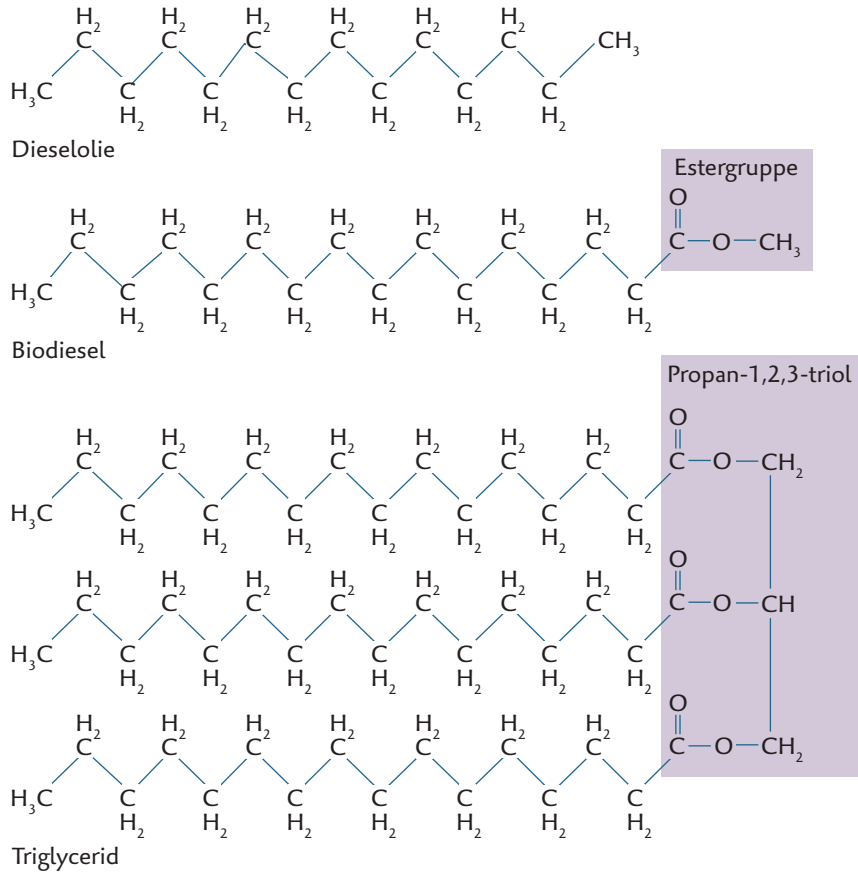
Figur 33. Lignocelluloses opbygning.
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Figur 34. Fremstilling af 2. generations bioethanol.
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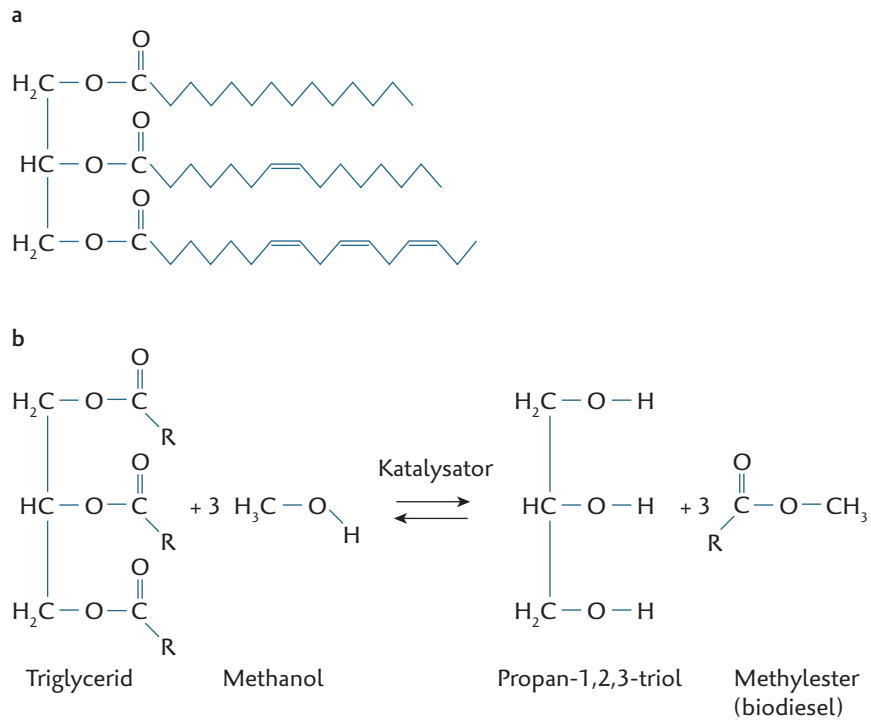
Figur 35. Spaltning af lignocellulose ved produktion af 2. generations bioethanol.
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Figur 36. Opbygning af dieselolie, biodiesel og triglycerid.

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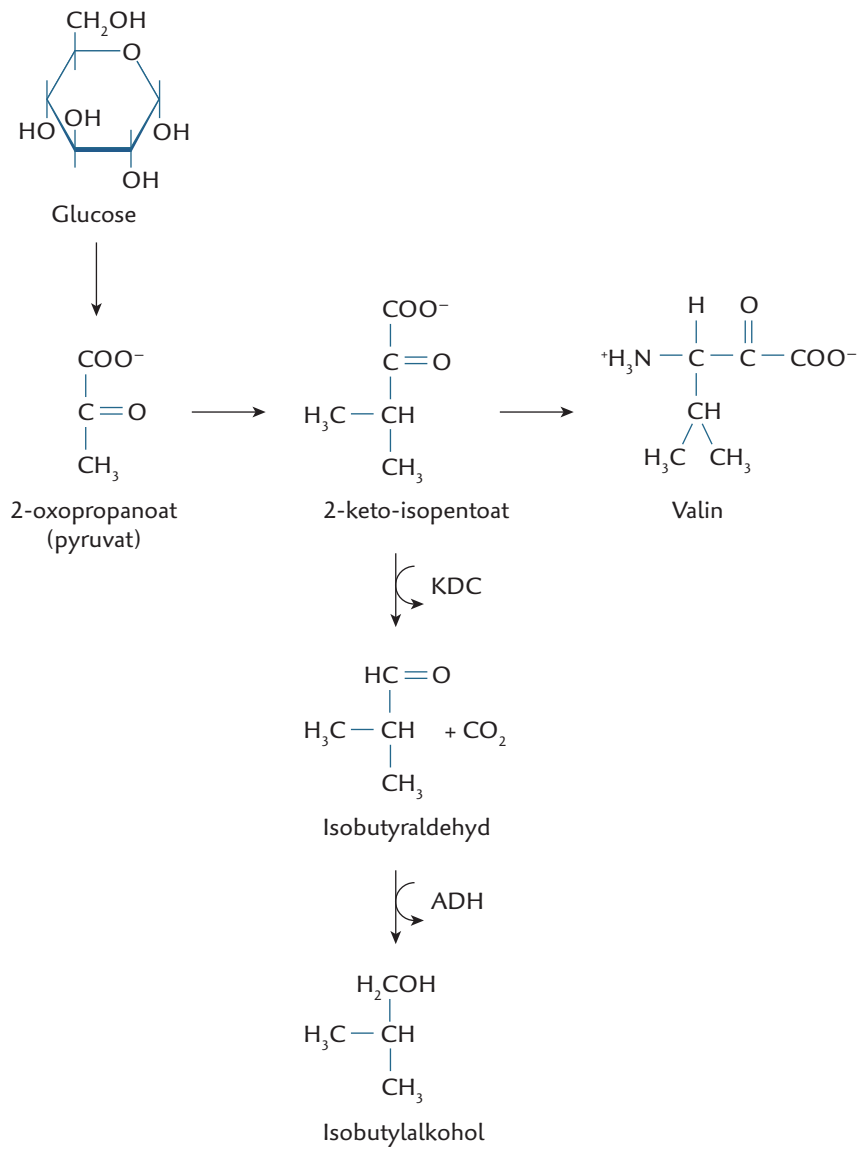
Illustration: Elin Steffensen, Gigraf · ISBN 978-87-90363-48-2.



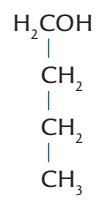
Figur 37. Triglycerid og omdannelse af triglycerid.

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Figur 38. Biosyntese af isobutylalkohol.
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Figur 39. Butylalkohol.

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