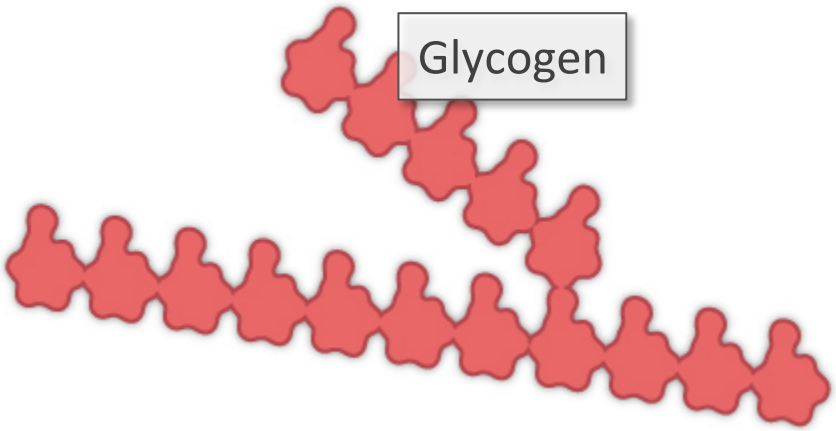
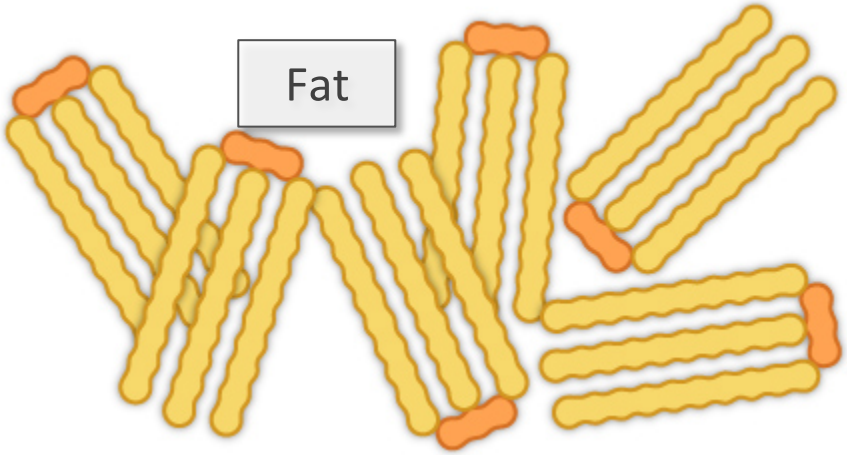
The Fat Paradox

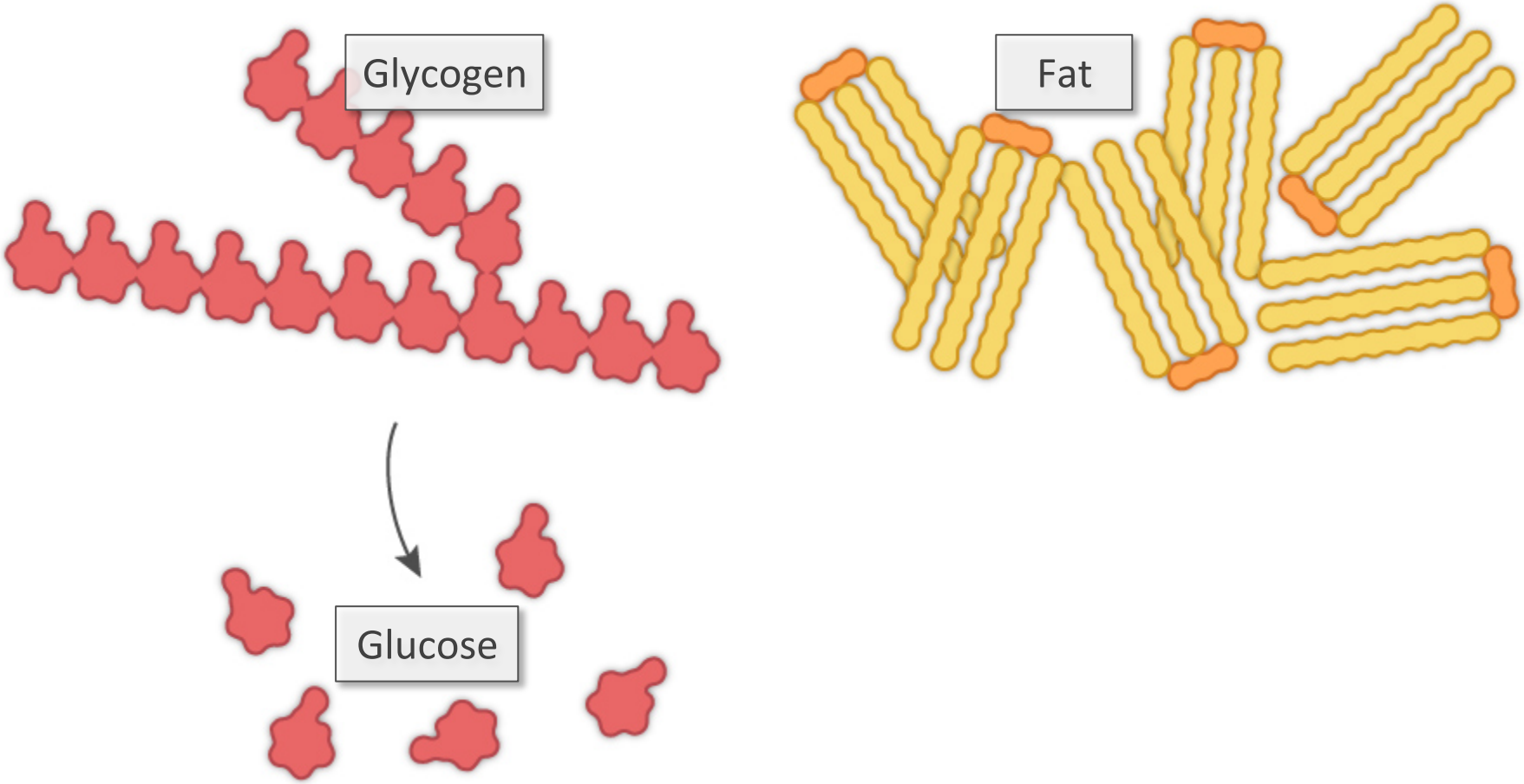
How fat keeps us skinny

The body stores energy two ways

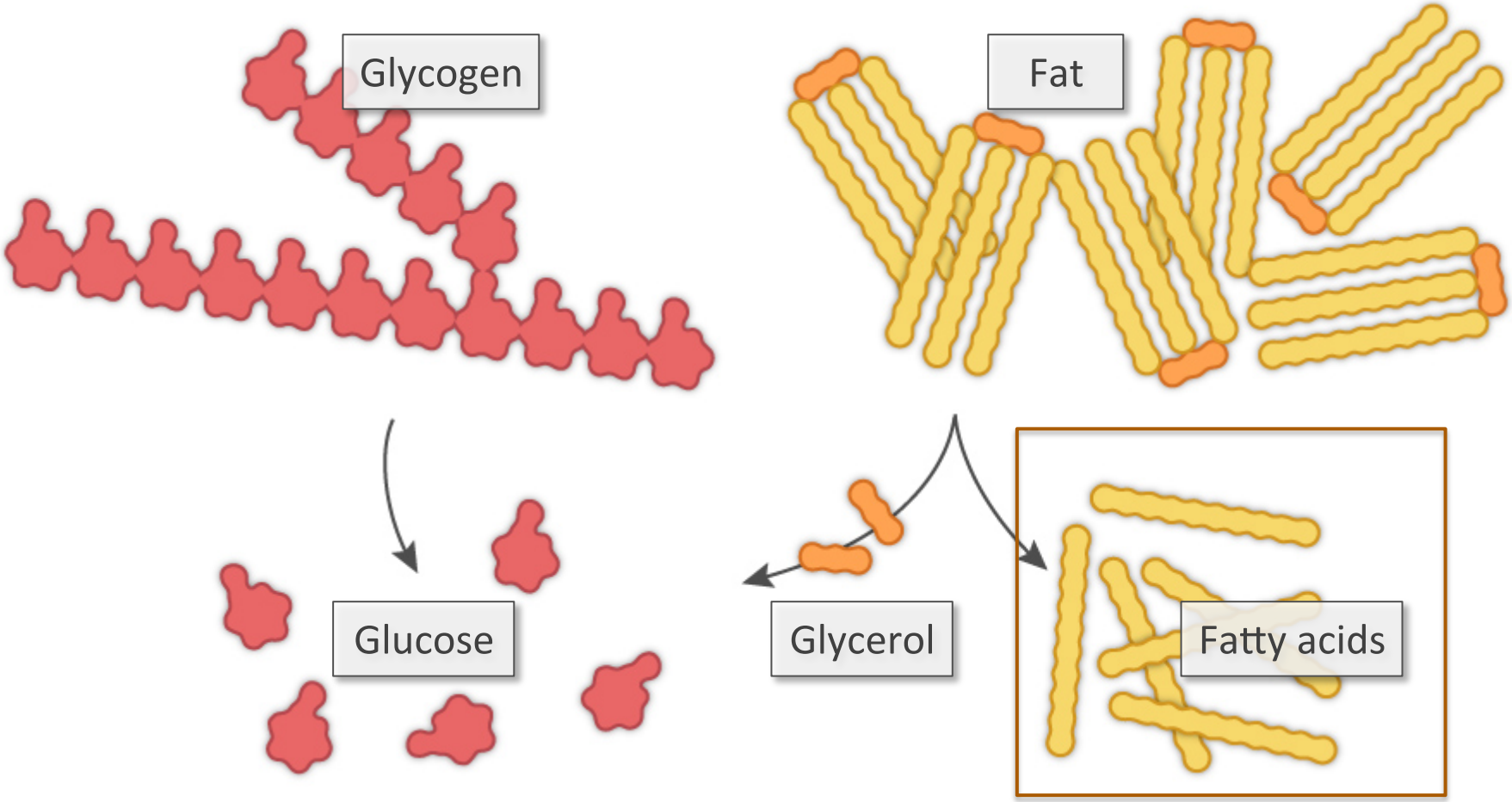




Glycogen can be converted to glucose

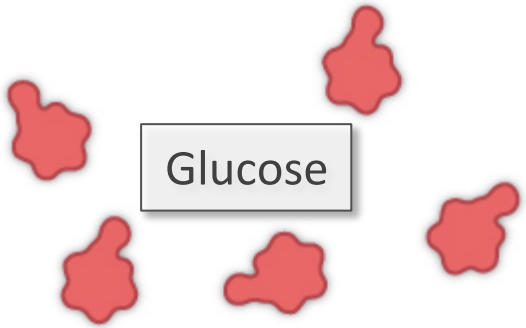


Fatty acids cannot be converted to glucose



Cells in the brain can burn glucose but not fatty acids

Food for the brain

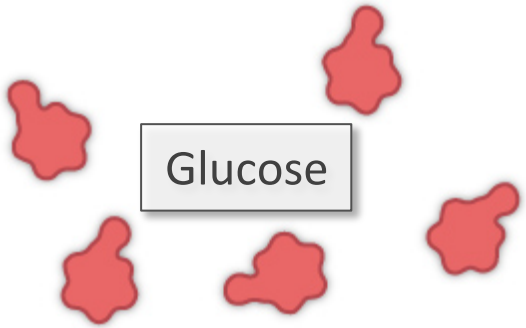


Brain cannot use

The brain uses 20% of the body's energy

- The body relies on a steady blood glucose level (too much or too little are both bad)

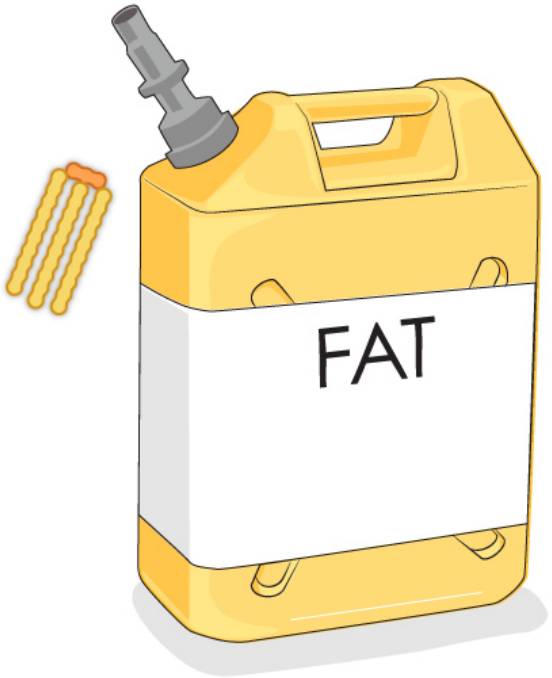
Food for the brain



Brain cannot use

Yet most energy is stored as fat

1,600 calories stored



135,000 calories stored

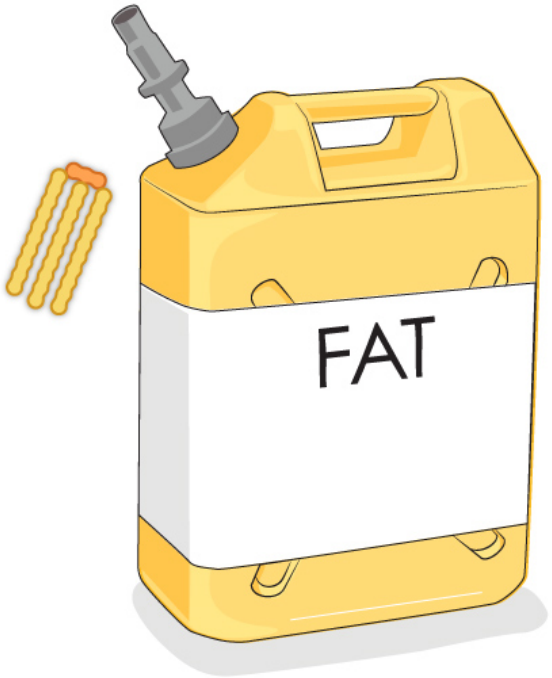
Based on a typical 154-pound man.

Reference: Cahill, G.F. (1976). J. Clin. Endocrinol. Metab. 5*:398.*

Fat stores more calories in less space

Dry weight = 4 calories/gram

Hydrated = 1.33 calories/gram



9 calories/gram

Reference: Berg, J.M., Tymoczko, J.L., Stryer, L. (2002). Biochemistry*, fifth edition. New York: W.H. Freeman.*

Fat stores more calories in less space

135,000 calories

- Stored as fat = 33 pounds
- Stored as hydrated glycogen = 223 pounds

Implications for weight loss

- When we restrict calories, glycogen is depleted quickly (1 to a few days)

1,600 calories stored

2.6 pounds

Implications for weight loss

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1,600 calories stored

2.6 pounds

Depleting glycogen alone can result in a rapid 2.6-pound weight loss. This is why dieters often feel successful after the first week.

Implications for weight loss

2.6 pounds of glycogen is very different from 2.6 pounds of fat!

1,600 calories

2.6 pounds of glycogen

10,600 calories

2.6 pounds of fat

Fat stores more calories in less space

135,000 calories

- Stored as fat = 33 pounds
- Stored as hydrated glycogen = 223 pounds

33 pounds of glycogen vs. fat

20,000 calories

- 10 days

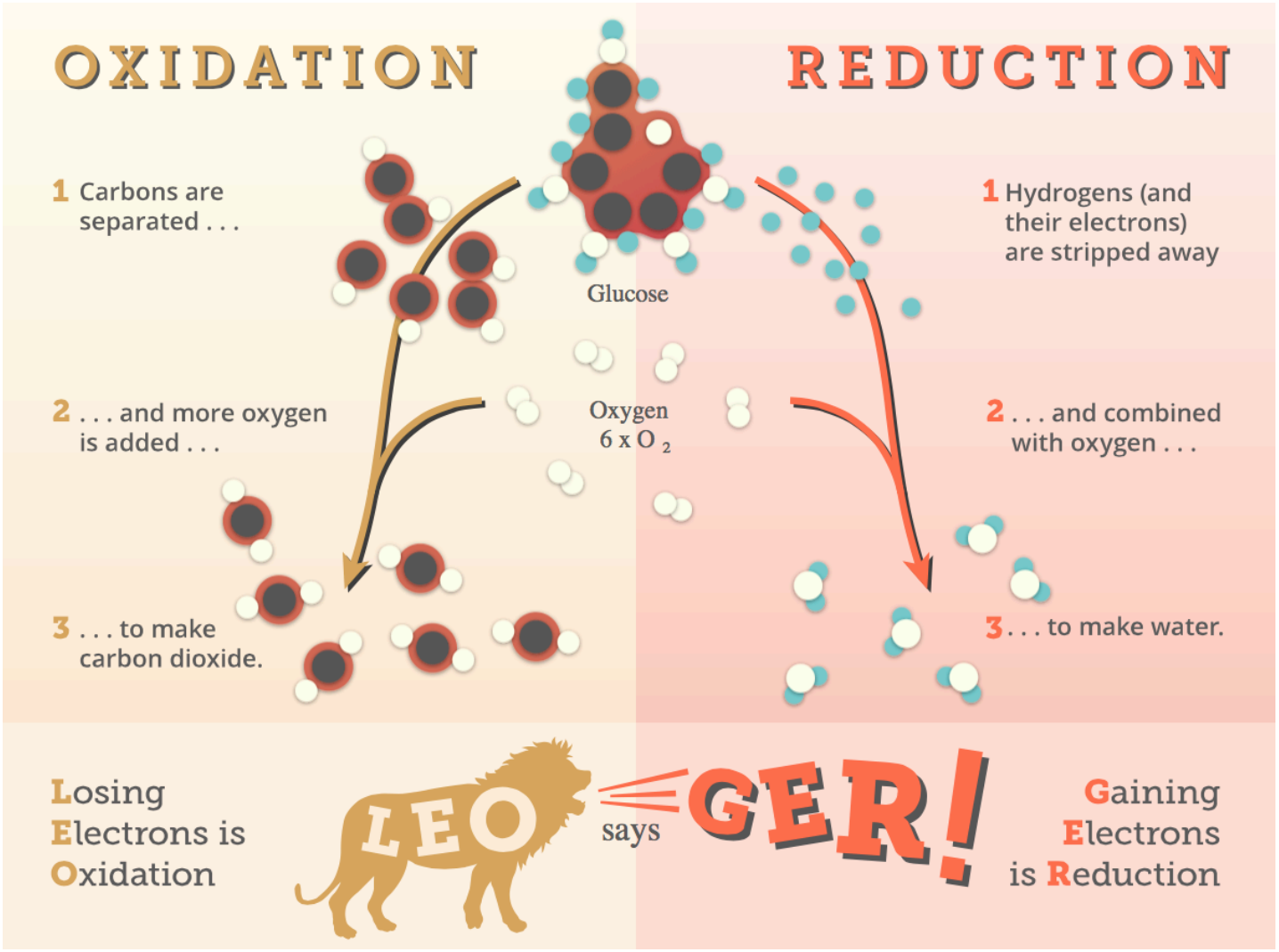
135,000 calories

- 68 days

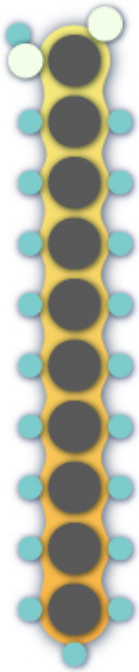
Fat can keep us alive for much longer

(based on 2,000 calories per day)

Chemistry

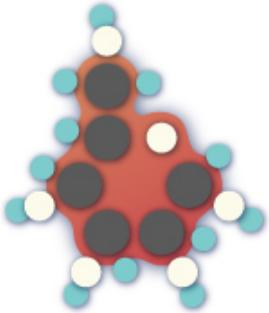


Chemistry



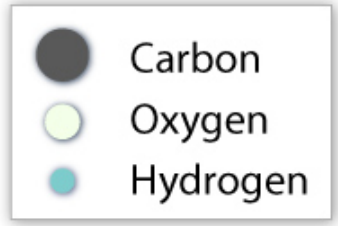
Decanoic acid

$C_{10}H_{20}O_2$



Glucose

$C_6H_{12}O_6$



- The carbons in fatty acids have more hydrogens (electrons) to lose during oxidation.
- Loss of electrons = more energy transferred.

Implications for evolution

- Fat allows us to carry a large energy reserve
- Storing more energy as fat conveyed a selective advantage: those with more fat reserves were more likely to survive famine and reproduce
- Excess fat storage was good.

Challenges for today

- Even though food is plentiful in the modern world, the body is still hard-wired to store extra energy as fat.
- Excess calories lead to excess fat. Today, obesity and related health problems are common