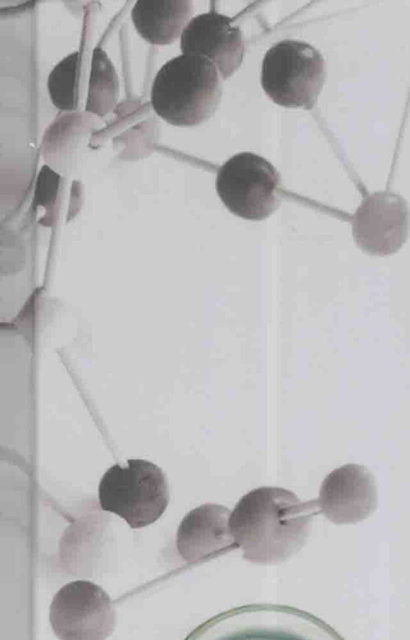

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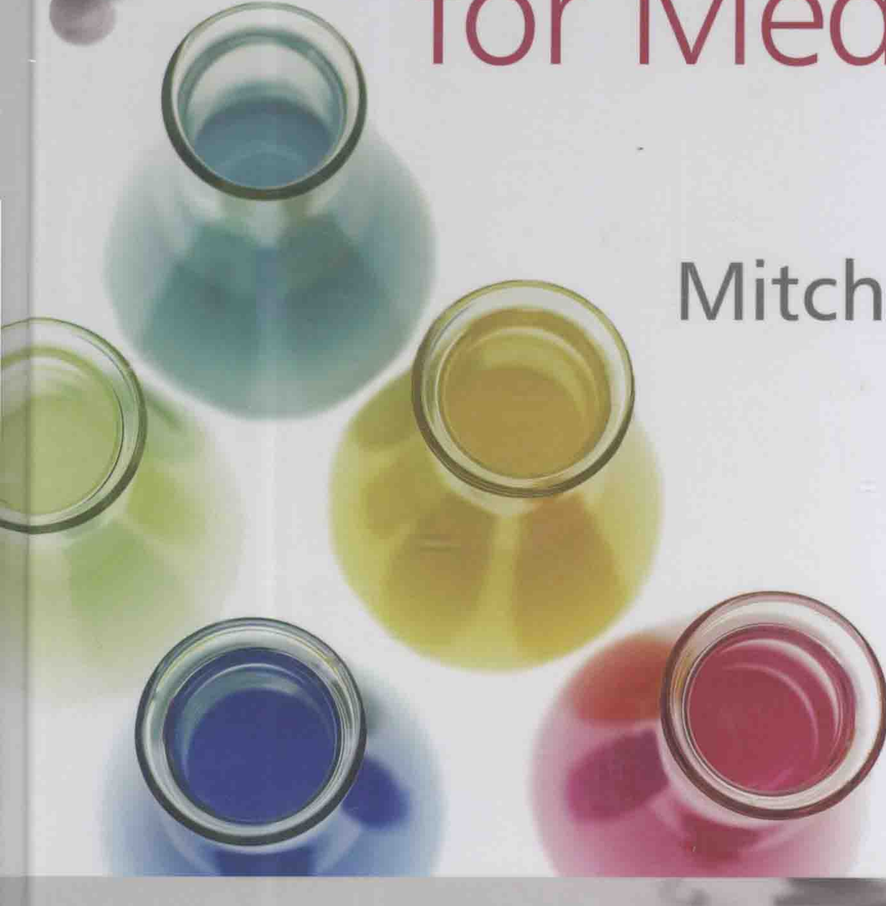

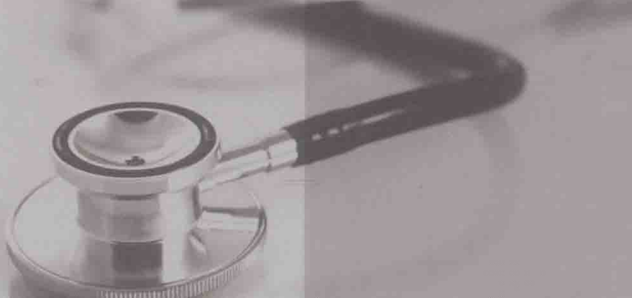

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Essential Biochemistry for Medicine

Preface

To the uninitiated, biochemistry is a complex and intricate subject, but importantly it is a subject that underpins the biosciences, including medicine. As a university lecturer, and by training a biochemist, I have taught my subject to both 'my own' students, and to those on allied degree schemes and pre-clinical medicine. Of course, the lines so conveniently drawn (for teaching purposes) between the different bio-disciplines are very artificial; there is far more commonality than difference between these subjects. As a biochemist I am pleased to see the subject have such eminence, and rightly so, but at the same time it should not be delivered as a *fate accompli*, but rather as an aid to understand and clarify, a foundation to build upon and allow explanation. When I set out to write this book, it was not my intention to write a 'biochemistry' text, nor a 'medical' text, but rather something that provided a more complete picture. This is not meant to be a reference work, but rather a companion, and hopefully one that accurately reflects the type, depth and amount of biochemistry that is appropriate for medical and biomedical undergraduate students alike.

Essential Biochemistry for Medicine should provide a useful and helpful supplement to lectures and workshops, a biochemical–physiological–medical continuum, full of numerous medical examples, additional factual material and FOCUS sections on some favourite medical topics. I have tried to keep the book simply presented but packed with information, and it contains a full index to aid quick navigation. Indeed, it may be the only biochemistry book you need.

Mitch Fry

Contents

CHAPTER 1

Nutritional requirements

Food consists of water, macronutrients (carbohydrates, fats and proteins) and micronutrients (vitamins, minerals).

The amount of energy contained in food is typically measured in calories; a dietary calorie (C) is actually a thousand calories (kcal) (*a calorie is defined as the amount of heat energy that is required to increase the temperature of 1 gram of water by 1 degree Celsius*). Carbohydrates (a hydrated energy source) and proteins produce about 4 kcal per gram, while fat (an anhydrous energy source) produces about 9 kcal of heat per gram.

1.1 Carbohydrates and sugars

Carbohydrates are mostly used for energy; limited amounts can be stored in the liver and muscles in the form of glycogen. They vary widely in their complexity, and in the speed with which they are digested and metabolised. Sugars are a class of carbohydrates. Sugar monosaccharides include glucose, fructose and galactose. Disaccharides, composed of two monosaccharide units, include sucrose (common table sugar, glucose and fructose), lactose (found mostly in milk), glucose and galactose (Figure 1.1).

Polysaccharides are polymers of monosaccharides. Starch is a polysaccharide composed of amylose, an essentially linear polysaccharide, and amylopectin, a highly branched polysaccharide; both are polymers of D-Glucose.

Amylose (Figure 1.2) consists typically of 200–20 000 glucose units, which form a helix as a result of the bond angles between the units; the linkages between glucose molecules are referred to as 1–4 (between carbon 1 and carbon 4 of adjacent glucose molecules; see Figure 1.1 for numbering of ring structure).

Amylopectin differs from amylose in being highly branched. Short side chains of about 30 glucose units are attached with 1–6 linkages approximately every 20–30 glucose units along the chain.

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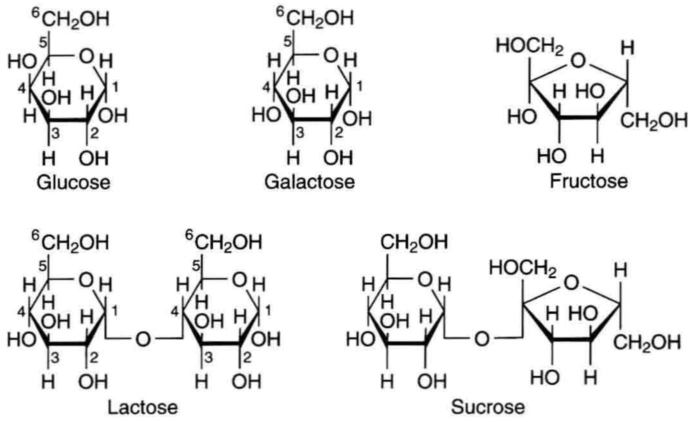

Figure 1.1 Simple sugar structures.

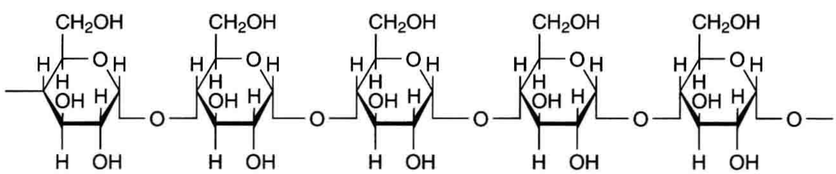

Figure 1.2 Amylose.

1.2 Glycogen

Glycogen is similar in structure to amylopectin, but branches more frequently (Figure 1.3). Starch and glycogen polysaccharides provide structures that are used for energy storage, in plants and animals respectively.

Fibre is a polymer carbohydrate. Most fibre is derived from the cell walls of plants and is indigestible, for example cellulose.

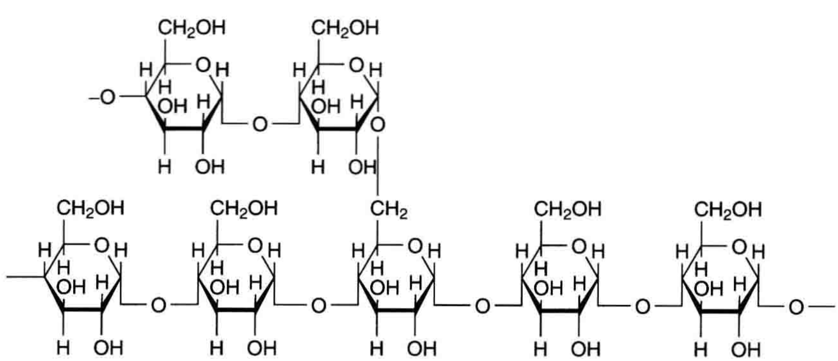

Figure 1.3 Glycogen.

Table 1.1 Glycaemic indices of some common foods.

Classification	GI range	Common examples
Low GI	55 or less	Most fruit and vegetables (except potatoes, watermelon), grainy breads, pasta, legumes/pulses, milk, products that are low in carbohydrates (e.g. fish, eggs, meat, nuts, oils), apples.
Medium GI	56–69	Whole wheat products, brown rice, basmati rice, sweet potato, table sugar, ice cream.
High GI	70–99	Corn flakes, baked potato, watermelon, boiled white rice, croissant, white bread.
	100	Pure glucose.

1.3 Glycaemic index

The ability of the body to digest different carbohydrates can be described by the glycaemic index (GI) (Table 1.1).

Low GI foods release glucose more slowly and steadily; high GI foods cause a more rapid rise in blood glucose levels. The latter are suitable for energy recovery after endurance exercise or for a person with diabetes experiencing hypoglycaemia. Only foods containing carbohydrates have a glycaemic index. Fats and proteins have little or no direct effect on blood sugar.

1.4 Lipids

Lipids (fats) provide energy and constitute a major energy store, as well as being an important body mass builder. Up to 20% of a healthy male's total weight comprises fat; this can be as much as 25% in females. Fat is a normal and healthy constituent of the body, cushioning internal organs from shock and providing heat insulation. As an energy source, fat contains over twice the energy per gram as does carbohydrate. Carbohydrates (in the form of glucose) are typically used to provide rapid energy, while fat is burned during sustained exercise. Fat is the primary fuel of choice during slow aerobic exercise, while glucose is used during fast aerobic or anaerobic exercise.

Lipids include fats and oils; oils tend to be liquid at room temperature, fats tend to be solid.

A fat molecule consists of one molecule of glycerol, bonded by dehydration synthesis (the loss of water) to three fatty acid molecules (this is a triacylglycerol, Figure 1.4). Fatty acids are

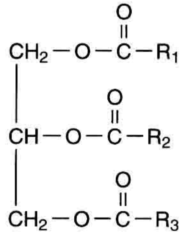

Figure 1.4 A triacylglycerol molecule. The glycerol backbone is bonded to three fatty acids (R_1, R_2 and R_3).