

Chapter 21

INTRODUCTION TO METABOLIC PATHWAYS

0000 The metabolic activities of cells are dictated by two major concerns:

- 00010 1. *The cell has to synthesize its macromolecules.* Proteins have to be synthesized from amino acids, complex carbohydrates from monosaccharides, membrane lipids from fatty acids and other building blocks, and nucleic acids from nucleotides (pathway ① in Fig. 21.1). These biosynthetic processes are called **anabolic**. They require metabolic energy in the form of adenosine triphosphate (ATP).
- 00015 2. *The cell has to generate metabolic energy.* Nutrients must be oxidized to supply ATP for biosynthesis, active membrane transport, cell motility, and muscle contraction. Degradative processes are called **catabolic**. Most ATP is produced during the **end-oxidation** of metabolic intermediates to CO_2 and H_2O in the mitochondria (pathway ② in Fig. 21.1).

Therefore an unsuspecting nutrient molecule entering a cell has two alternative fates: either it becomes incorporated into a cellular macromolecule, or it is oxidized for the generation of ATP.

00020 The biosynthesis of cellular macromolecules has to be balanced by their degradation (pathway ③ in Fig. 21.1). Under steady-state conditions, the rates of synthesis and degradation are balanced and the amount of the macromolecule remains constant. Different nutrients can also be interconverted through metabolic intermediates. For example, most amino acids can be converted to glucose, and glucose can be converted to amino acids and fatty acids.

ALTERNATIVE SUBSTRATES CAN BE OXIDIZED IN THE BODY

00025 The complete oxidation of carbohydrates and protein yields about 17 kJ/g (4 kcal/g), fat 37 kJ/g (9 kcal/g), and alcohol 29 kJ/g (7 kcal/g). Molecular oxygen is consumed during fuel oxidation, and carbon dioxide is produced:



Glucose



Tripalmitate, a triglyceride

The stoichiometry of O_2 consumption and CO_2 production is described by the respiratory quotient (RQ):

$$\text{RQ} = \frac{\text{CO}_2 \text{ (produced)}}{\text{O}_2 \text{ (consumed)}}$$

The RQ for the oxidation of carbohydrates is 1.0; for fat, about 0.7; and for protein, about 0.8.

Most cells have a choice among alternative substrates including glucose, fatty acids, and amino acids. Others are more specialized. A few cell types, such as neurons and red blood cells, depend mainly or exclusively on glucose for their energy needs.

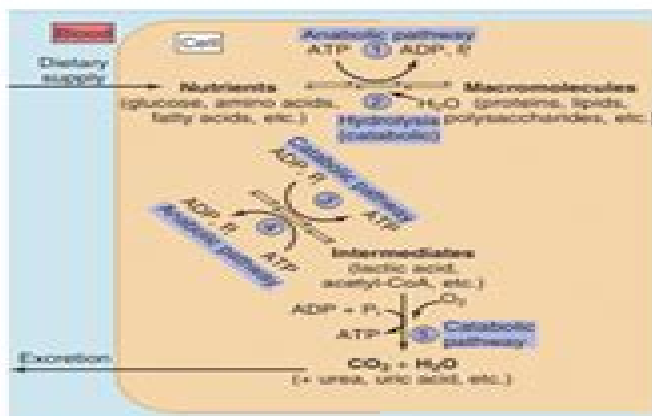


Fig. 21.1 Major types of metabolic activity in the cell. ADP, Adenosine diphosphate; ATP, adenosine triphosphate; CoA, coenzyme A; P_i , inorganic phosphate.

An Introduction To Metabolic Pathways

WJ Hussar

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Systems Biology Vincent Danos, Vincent Schachter, 2005-03-24 The Computational Methods in Systems Biology CMSB workshop series was established in 2003 by Corrado Priami The purpose of the workshop series is to help catalyze the convergence between computer scientists interested in language design concurrency theory software engineering or program verification and physicists mathematicians and biologists interested in the systems level understanding of cellular processes Systems biology was perceived as being increasingly in search of sophisticated modeling frameworks whether for representing and processing syst level dynamics or for model analysis comparison and refinement One has here a clear cut case of a must explore field of application for the formal methods developed in computer science in the last decade This proceedings consists of papers from the CMSB 2003 workshop A good third of the 24 papers published here have a distinct formal methods origin we take this as a confirmation that a synergy is building that will help solidify CMSB as a forum for cross community exchange thereby opening new theoretical avenues and making the field less of a potential application and more of a real one Publication in Springer s new Lecture Notes in Bioinformatics LNBI offers particular visibility and impact which we gratefully acknowledge Our keynote speakers Alfonso Valencia and Trey Ideker gave challenging and somewhat humbling lectures they made it clear that strong applications to systems biology are still some way ahead We thank them all the more for accepting the invitation to speak and for the clarity and excitement they brought to the conference

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