

Absorption of Toxicants

Principles of Environmental Toxicology
 Instructor: Gregory Möller, Ph.D.
 University of Idaho

Learning Objectives

- Describe the ways in which toxicants interact with cells.
- Recognize how the molecular characteristics of toxicants affect entrance into a cell.
- Explain human anatomy as related to integumentary, respiratory and digestive systems.
- Summarize the routes of toxicant absorption.

2

Organization of the Body

Levels of Structural Organization of the Body



3

© 1990 F. A. Davis Co., All Rights Reserved, Protected by Digimarc

Metabolism: Molecular Organization

Biosynthesis/Catabolism (Enzymes, ATP)

MONOMERS → POLYMER

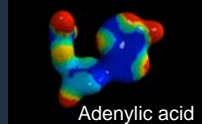
subunits → macromolecules

saccharides → polysaccharides

glucose → glycogen

amino acids → proteins

nucleotides → DNA, RNA

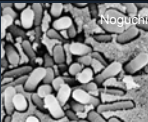


4

Noguchi

Composition of Bacteria

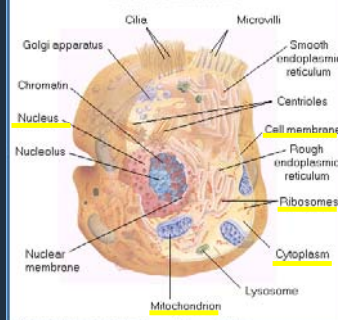
E. coli	% of total weight	Types of molecules
Water	70	1
Proteins	15	3000*
Nucleic Acids		
DNA	1	1
RNA	6	>3000*
Polysaccharides	3	5
Lipids	2	20
Building block molecules	2	500
Inorganic ions	1	20



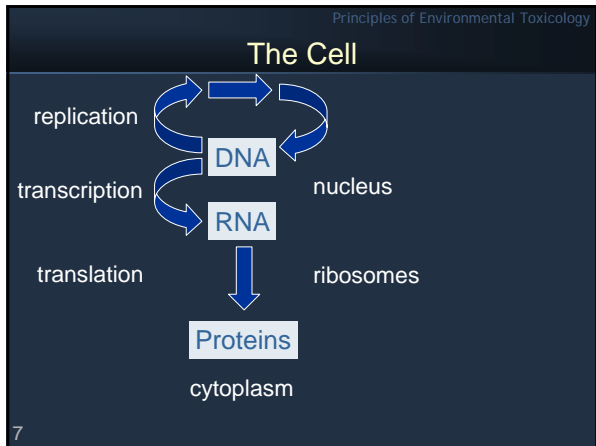
5

Cell Structure

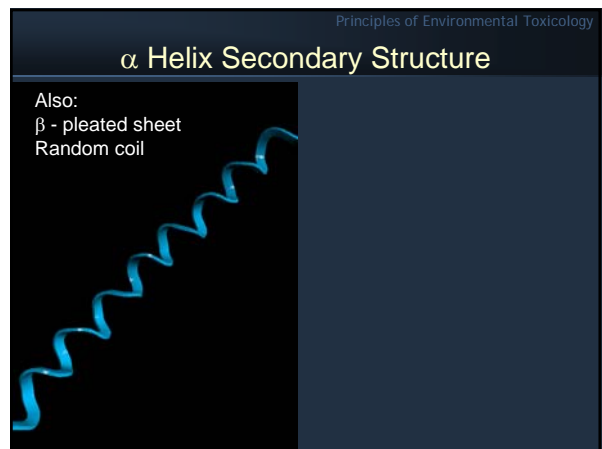
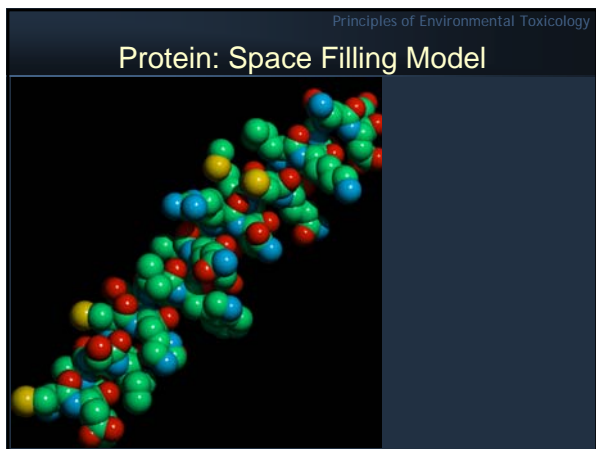
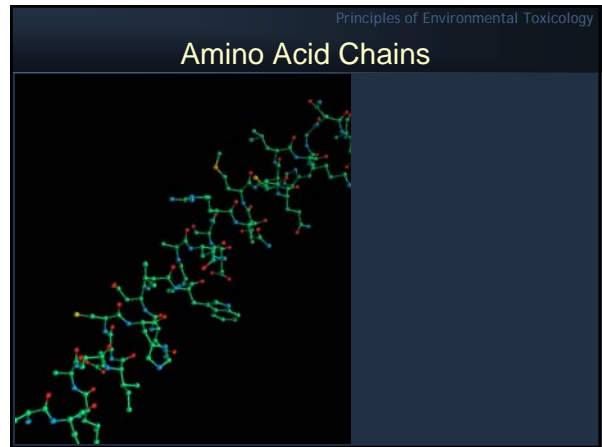
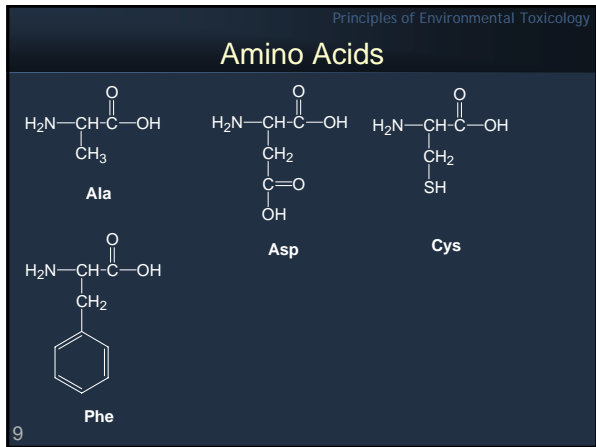
Basic Cell Structure



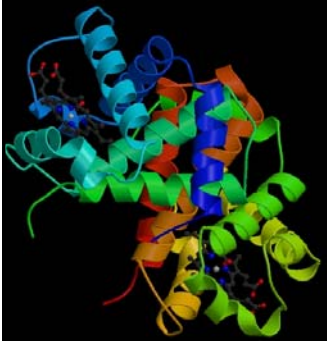
© 1990 F. A. Davis Co., All Rights Reserved, Protected by Digimarc



- Principles of Environmental Toxicology
- ### Proteins
- Synthesized primarily during a process called translation.
 - Building blocks of proteins are amino acids.
 - Proteins are made of a long chain of amino acids
 - Peptide bonds; disulfide bonds (Cys).
 - Primary structure is sequence.
 - Sometimes modified by:
 - Heme, sugars, phosphates.
- 8



Hemoglobin Protein Structure



Protein Functions

- **Antibodies.**
 - Recognize molecules of invading organisms.
- **Receptors.**
 - Part of the cell membrane; recognize other proteins, or chemicals, and inform the cell.
- **Enzymes**
 - Assemble or digest.
- **Neurotransmitters, hormones**
 - Trigger receptors.
- **Channels and pores.**

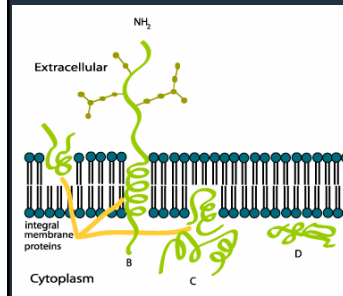
14 Rothamsted

Cellular Absorption

- **Diffusion.**
 - Requires concentration gradient.
 - Fick's Law.
- **Facilitated diffusion.**
 - Membrane surface carrier proteins.
 - Glucose transport.
- **Active transport.**
 - Requires cellular energy (ATP).
 - Endo/exo-cytosis.
 - Phago/pino-cytosis.

15

Cell Membrane Phospholipid bilayer



16

Four Types of Cells

- **Epithelia.**
 - Coverings, linings, secretions.
- **Connective.**
 - Support, energy.
- **Muscle.**
 - Movement.
- **Nervous.**
 - Electrical impulse, information.

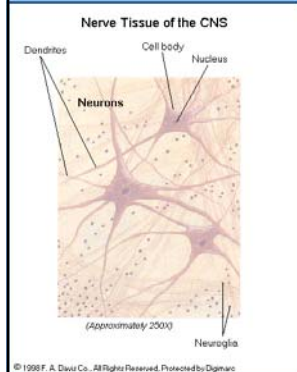
17

Epithelia

Classification of Epithelial Tissues		
Shapes	Simple	Stratified
 Squamous	 Simple squamous	 Stratified squamous
 Cuboidal	 Simple cuboidal	
 Columnar	 Simple columnar	

© 1998 F. A. Davis Co., All Rights Reserved, Protected by Digimarc

Nerve

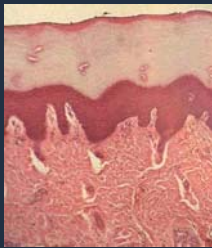


Eleven Organ Systems

- Integumentary
- Skeletal
- Muscular
- Nervous
- Endocrine
- Cardiovascular
- Lymphatic
- Digestive
- Respiratory
- Urinary
- Reproductive

Absorption

- Process by which toxicants cross the epithelial cell barrier.



Routes of Absorption

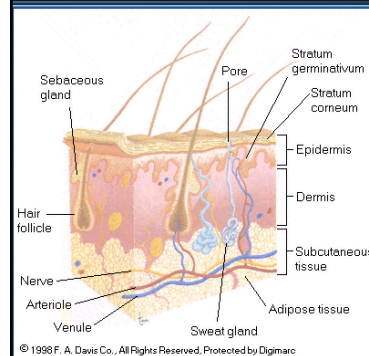
- Integumentary (percutaneous).
- Respiratory.
- Digestive.



Integumentary System Route

- Skin, hair, nails, mammary glands.
 - Skin is the largest organ in the body.
- Epidermis.
 - Avascular, keratinized stratum corneum, 15-20 cells thick, provides most toxicant protection.
- Dermis.
 - Highly vascularized; nerve endings, hair follicles, sweat and oil glands.
- Hypodermis.
 - Connective and adipose tissue.

Skin



Case Study: Skin Lesion

Kenyan Beetle Toxin



Some beetles have mixing chambers in their abdomens that produce a hot, violently exploding, poison. This quinone based toxin can be directed at threats.

Bombardier beetles related to the genus *Brachinus*.



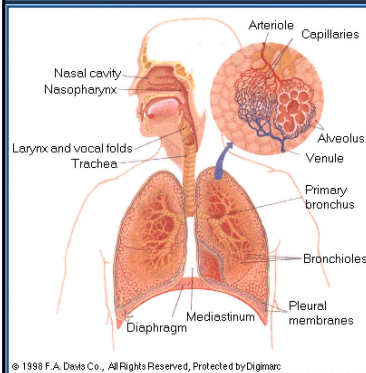
25

Respiratory System Route

- Skin: stratified squamous epithelial tissue.
- Respiratory system: squamous epithelium, ciliated columnar and cuboidal epithelium.
 - Non-keratinized, but ciliated tissues and mucus-secreting cells provide “mucociliary escalator”.
- Nasopharyngeal.
- Tracheobronchial.
- Pulmonary.

26

Respiratory Tract



Respiratory System Route, 2

- Nasopharyngeal.
 - Nostrils, nasopharynx, oropharynx, laryngopharynx.
 - Hairs and mucus; trap >5 μm particulates.
- Tracheobronchial.
 - Trachea, bronchi, bronchioles; cillial action.
 - Luminal mucus traps 2-5 μm particulates and H₂O soluble aerosols and gases.
- Pulmonary
 - Alveoli - high surface area gas exchange with cardiovascular system.

28

Lung Dissection

Bovine



Bronchus-Bronchiole Dissection



Respiratory Toxicosis

December 3, 1984 methyl isocyanate release kills 10,000 in Bhopal, India



31

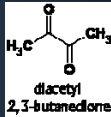
Case Study: Fixed Obstructive Lung Disease in Workers at a Microwave Popcorn Factory Missouri, 2000--2002

- In May 2000, an occupational medicine physician contacted the Missouri Department of Health and Senior Services (MoDHSS) to report eight cases of fixed obstructive lung disease in former workers of a microwave popcorn factory. Four of the patients were on lung transplant lists.
 - All eight had a respiratory illness resembling bronchiolitis obliterans (chronic scarring) with symptoms of cough and dyspnea on exertion, had worked at the same popcorn factory at some time during 1992--2000

32 Morbidity and Mortality Weekly Report, April 26, 2002 / 51(16):345-7

Diacetyl Butter Flavor

- Industrial hygiene sampling conducted during the November 2000 survey detected approximately 100 VOCs in the plant air.
- Diacetyl, a ketone with butter-flavor characteristics, was measured as a marker for exposure to flavoring vapors. The geometric mean air concentration of diacetyl was 18 ppm in the room air where the mixing tank was located, 1.3 ppm in the microwave packaging area, and 0.02 ppm in other areas of the plant.
- Rates of obstructive abnormalities on spirometry increased with increasing cumulative exposure to airborne flavoring chemicals.



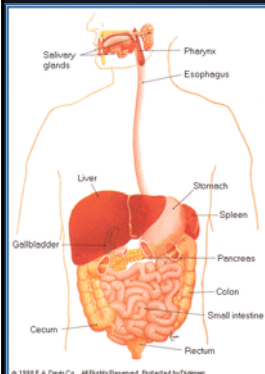
33

Digestive System Route

- Mouth, oral cavity, esophagus, stomach, small intestine, rectum, anus.
- Residence time can determine site of toxicant entry/injury.
 - Mouth (short); small intestine (long).
 - Absorption of toxicants can take place anywhere, but much of the tissue structure in the digestion system is specially designed for absorption.

34

Gastrointestinal Tract



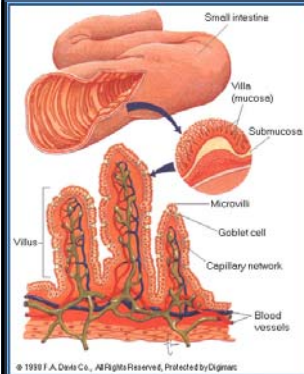
© 1999 F. A. Davis Co., All Rights Reserved. Reprinted by permission.

Digestive System Route, 2

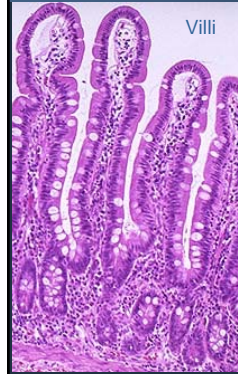
- Tissue differentiation.
- Mucosa
 - Avascular, s. squamous or columnar epithelium.
 - In some regions villi and microvilli structure aids in absorption (high surface area).
- Submucosa
 - Blood, lymph system interface.
- Muscularis (movement).
- Serosa (casing).

36

Intestine



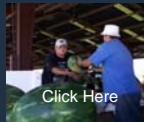
Small Intestine Mucosa



Villi
Microscopic View
Histology Slide

Pesticide Food Poisoning

At 4 a.m., July 4, 1985, three adults who ate a solid green watermelon purchased in Oakland, California, had rapid onset of nausea, vomiting, diarrhea, profuse sweating, excessive tearing, muscle fasciculations, and bradycardia. Aldicarb, a carbamate insecticide and potent AChE inhibitor not registered for watermelons, was found in the samples. In the next month, 762 probable or possible cases were reported. The most severe signs and symptoms included seizures, loss of consciousness, cardiac arrhythmia, hypotension, dehydration, and anaphylaxis.



[Click Here](#)