

Absorption of Toxicants

Principles of Environmental Toxicology
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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.

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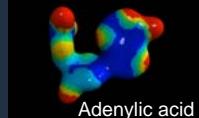
Organization of the Body



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Metabolism: Molecular Organization

Biosynthesis/Catabolism (Enzymes, ATP)



MONOMERS → POLYMER

subunits	→	macromolecules
saccharides	→	polysaccharides
glucose	→	glycogen
amino acids	→	proteins
nucleotides	→	DNA, RNA

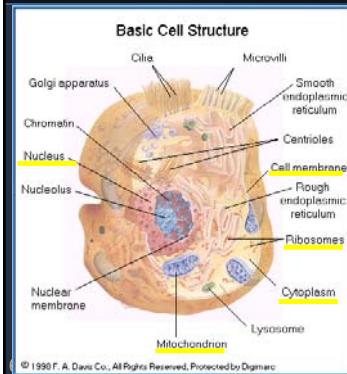
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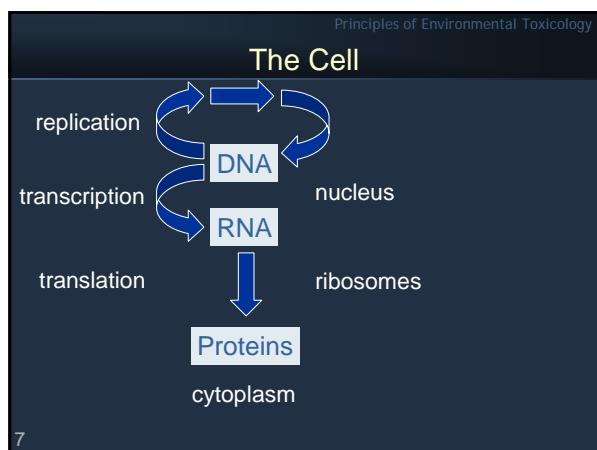
Composition of Bacteria

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

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Cell Structure



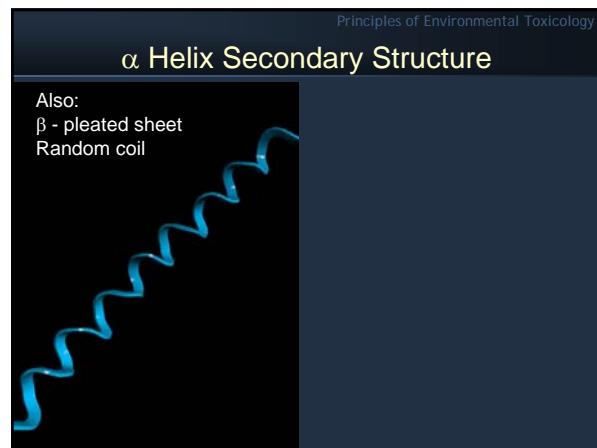
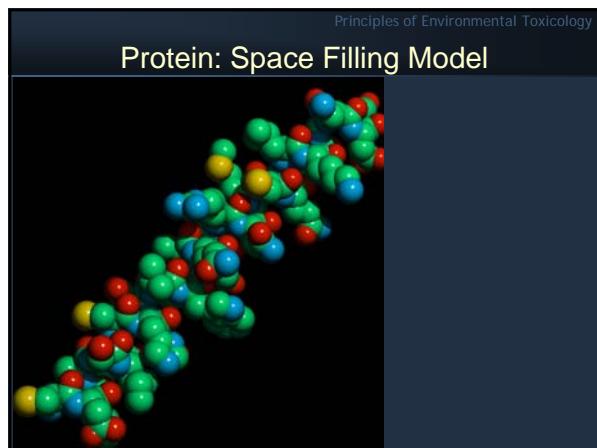
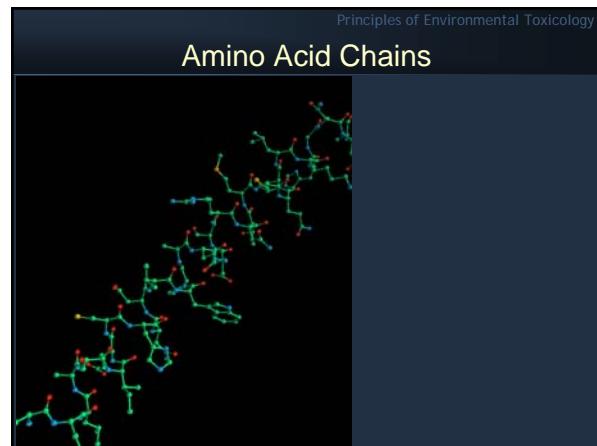
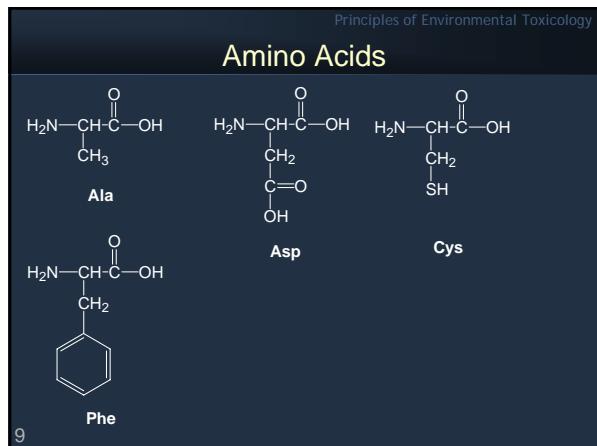


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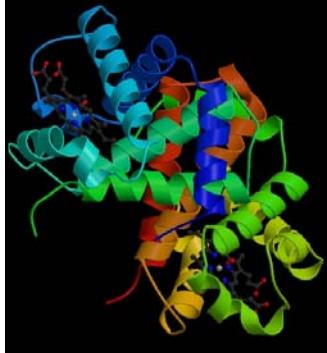
Proteins

- 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.

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Hemoglobin Protein Structure



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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.**

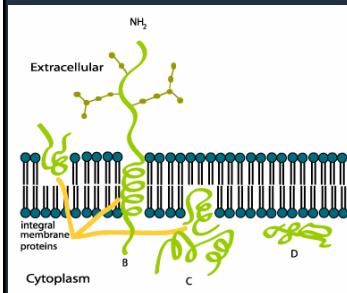
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Cellular Absorption

- **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.

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Cell Membrane Phospholipid bilayer



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Four Types of Cells

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

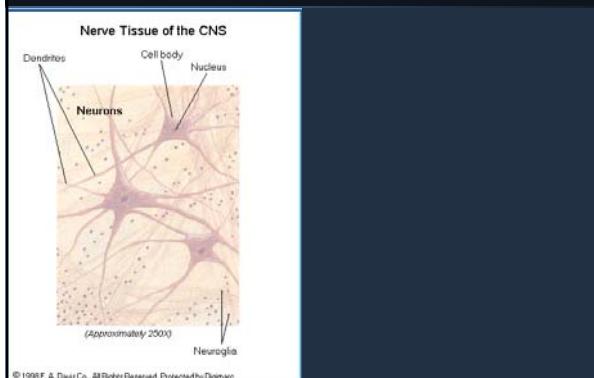
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Epithelia

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

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Nerve



Eleven Organ Systems

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

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Absorption

- Process by which toxicants cross the epithelial cell barrier.

A micrograph of skin tissue, showing the multi-layered epidermis on top and the thicker, more cellular dermis below. The epidermis appears as a pinkish-red layer with distinct boundaries, while the dermis is a darker, more uniform color.

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Routes of Absorption

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

A photograph of a person wearing a full-body white protective suit, a blue surgical mask, and yellow gloves. The person is standing at a workbench, holding a small vial and a dropper, possibly conducting a controlled experiment or analysis in a laboratory environment.

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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.

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Skin

A detailed diagram of a cross-section of skin. It shows the epidermis, which is further divided into the stratum germinativum (bottom layer) and stratum corneum (top layer). Below the epidermis is the dermis, containing hair follicles, sebaceous glands, sweat glands, and blood vessels. The hypodermis (subcutaneous tissue) is shown at the bottom, containing adipose tissue. A scale bar at the bottom left indicates the image is approximately 24x magnification. The image is from a 1998 F. A. Davis Co. publication.

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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.



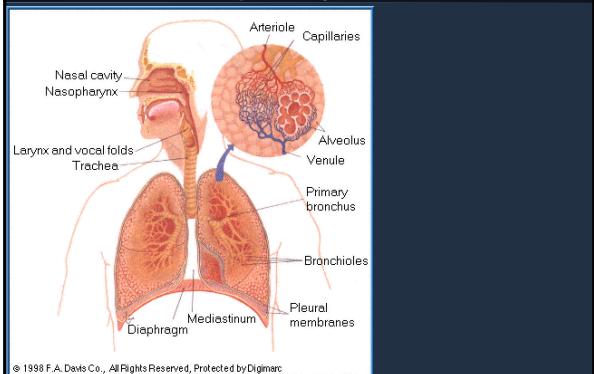
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Respiratory System Route

- 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.

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Respiratory Tract



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Respiratory System Route, 2

- Nasopharyngeal.
 - Nostrils, nasopharynx, oropharynx, laryngopharynx.
 - Hairs and mucus; trap $>5 \mu\text{m}$ particulates.
- Tracheobronchial.
 - Trachea, bronchi, bronchioles; cillial action.
 - Luminal mucus traps $2-5 \mu\text{m}$ particulates and H_2O soluble aerosols and gases.
- Pulmonary
 - Alveoli - high surface area gas exchange with cardiovascular system.

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Lung Dissection



Bronchus-Bronchiole Dissection



Respiratory Toxicosis

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



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Case Study: Fixed Obstructive Lung Disease in Workers at a Microwave Popcorn Factory

Missouri, 2000--2002

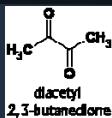
- In May 2000, an occupational medicine physician contacted the Missouri Department of Health and Senior Services (MoDHSS) to report eight cases of fixed obstructive lung disease in former workers of a microwave popcorn factory. Four of the patients were on lung transplant lists.

- 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

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.



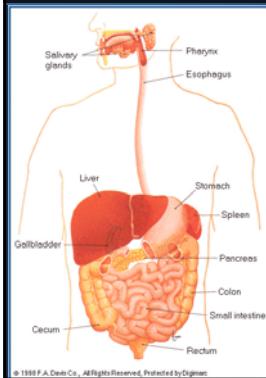
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Digestive System Route

- 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.

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Gastrointestinal Tract

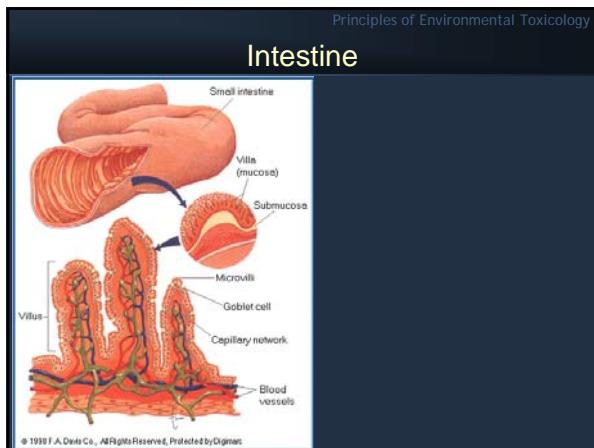


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Digestive System Route, 2

- Tissue differentiation.
- Mucosa
 - Avascular, s. squamus 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).

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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.



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