

Organic Chemistry and Medicine

A Sample Lecture from an Organic Chemistry Course
Designed for Pre-Med, Nursing, and Biology Students

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[Facebook.com/OrganicChemistOnCall](https://www.facebook.com/OrganicChemistOnCall)

Design of Course

A Few Common Observations...

Organic chemistry is typically taught from a chemical point of view

Organic chemistry is the one course *EVERYONE* has heard of and many DREAD taking

Organic chemistry is usually a “make it or break it” class for pre-med students

Does it have to be this way?

ABSOLUTELY NOT!!!

You can learn the same material that has been taught semester after semester at universities around the world but from a medical/biological point of view

Organic Chemistry and Medicine

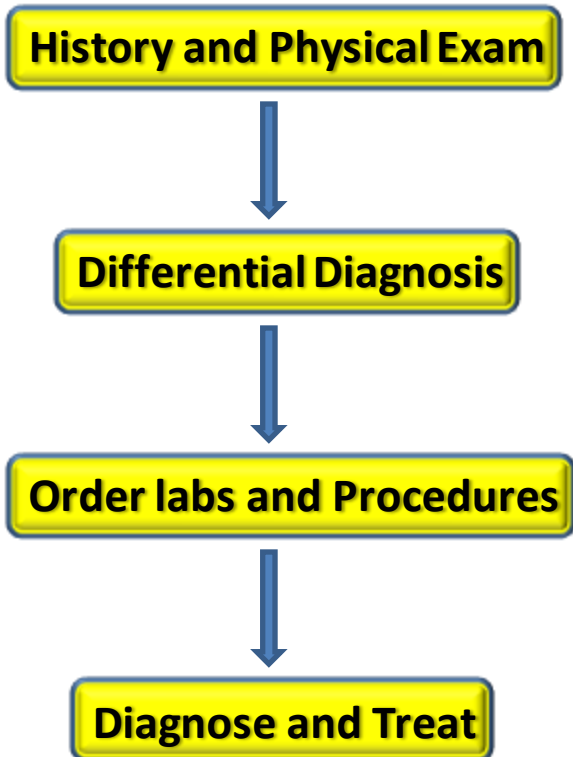
Or·gan·ic \ôr-'ga-nik\ *adj* : **1.** of, relating to, or arising in a bodily organ; **2.** of, relating to, or containing carbon compounds; **3.** relating to, being, or dealt with by a branch of chemistry concerned with the carbon compounds of living beings and most other carbon compounds

Chem·is·try \'ke-mə-strē\ *n* : a science that deals with the composition, structure, and properties of substances and with the transformations that they undergo

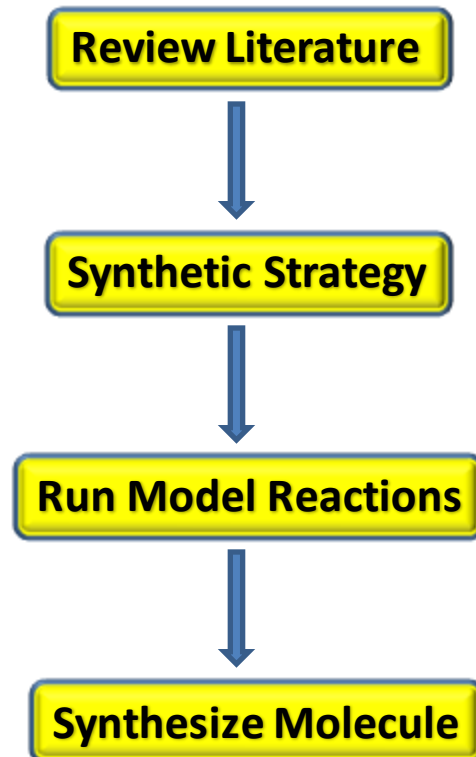
Med·i·cine \'me-də-sən\ *n* : **1.** a substance or preparation used in treating disease; **2.** the science and art dealing with the maintenance of health and the prevention, alleviation, or cure of disease

Organic Chemistry and Medicine

MEDICINE



ORGANIC CHEMISTRY



Organic Chemistry and Medicine

The format of the lectures will be as follows:

Presentation of Case Study

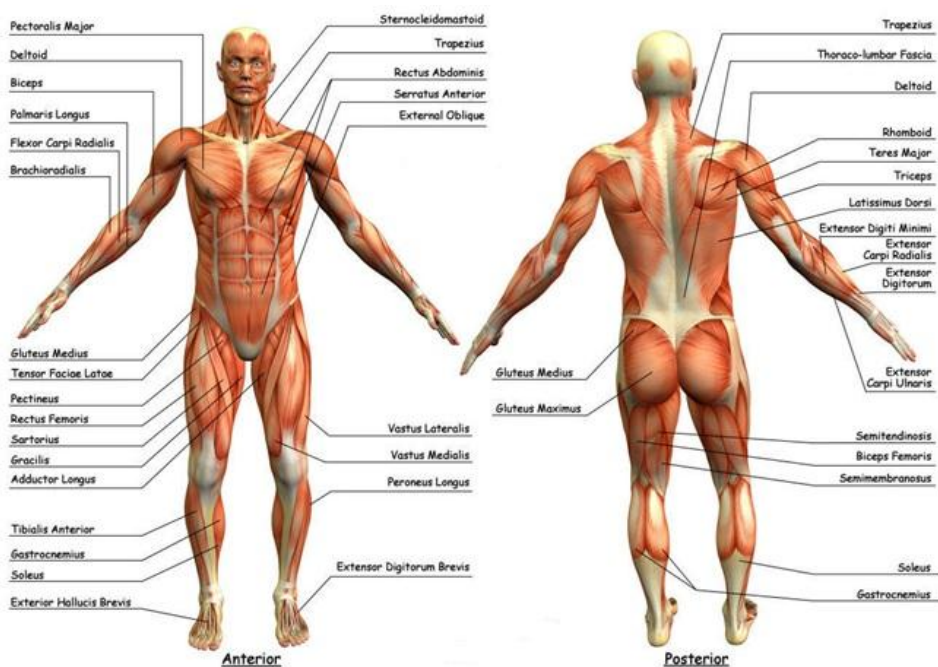
- Ex. 24 year old female presents to the ED with...

Discuss Functional Group(s)/Reaction(s)

- How this functional group/reaction(s) relates to the disease

Organic Chemistry and Medicine

Medicine



Blood, Plasma, Serum

	Reference Range	SI Reference Intervals
* Alanine aminotransferase (ALT, GPT at 30°C)	8-20 U/L	8-20 U/L
Amylase, serum	25-125 U/L	25-125 U/L
* Aspartate aminotransferase (AST, GOT at 30°C)	8-20 U/L	8-20 U/L
Bilirubin, serum (adult)		
Total // Direct	0.1-1.0 mg/dL // 0.0-0.3 mg/dL	2-17 µmol/L // 0-5 µmol/L
* Calcium, serum (Total)	8.4-10.2 mg/dL	2.1-2.8 mmol/L
* Cholesterol, serum	140-250 mg/dL	3.6-6.5 mmol/L
* Creatinine, serum (Total)	0.6-1.2 mg/dL	53-106 µmol/L
Electrolytes, serum		
Sodium	135-147 mEq/L	135-147 mmol/L
Chloride	95-105 mEq/L	95-105 mmol/L
* Potassium	3.5-5.0 mEq/L	3.5-5.0 mmol/L
Bicarbonate	22-28 mEq/L	22-28 mmol/L
Gases, arterial blood (room air)		
P _{O₂}	75-105 mmHg	10.0-14.0 kPa
P _{CO₂}	33-44 mmHg	4.4-5.9 kPa
pH	7.35-7.45	[H ⁺] 36-44 nmol/L
* Glucose, serum	Fasting: 70-110 mg/dL 2-h postprandial: < 120 mg/dL	3.8-6.1 mmol/L < 6.6 mmol/L
Growth hormone - arginine stimulation	Fasting: < 5 ng/mL provocative stimuli: > 7 ng/mL	< 5 µg/L > 7 µg/L
Osmolality, serum	275-295 mOsm/kg	275-295 mOsm/kg
* Phosphatase (alkaline), serum (p-NPP at 30°C)	20-70 U/L	20-70 U/L
* Phosphorus (inorganic), serum	3.0-4.5 mg/dL	1.0-1.5 mmol/L
* Proteins, serum		
Total (recumbent)	6.0-7.8 g/dL	60-78 g/L
Albumin	3.5-5.5 g/dL	35-55 g/L
Globulins	2.3-3.5 g/dL	23-35 g/L
* Urea nitrogen, serum (BUN)	7-18 mg/dL	1.2-3.0 mmol urea/L
* Uric acid, serum	3.0-8.2 mg/dL	0.18-0.48 mmol/L

Cerebrospinal Fluid

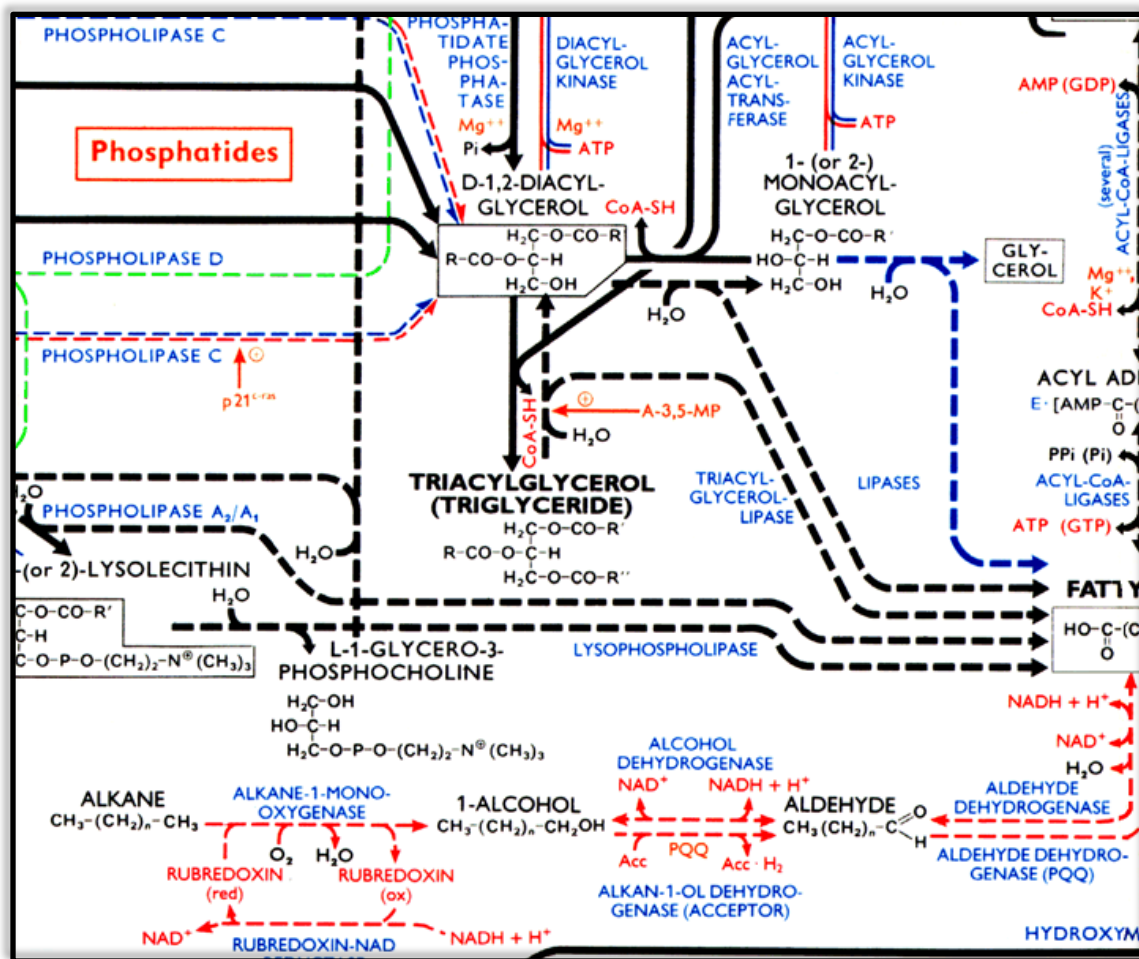
Glucose	40-70 mg/dL	2.2-3.9 mmol/L
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Hematologic

Erythrocyte count	Male: 4.3-5.9 million/mm ³ Female: 3.5-5.5 million/mm ³	4.3-5.9 × 10 ¹² /L 3.5-5.5 × 10 ¹² /L
Hematocrit	Male: 41-53% Female: 36-46%	0.41-0.53 0.36-0.46
Hemoglobin, blood	Male: 13.5-17.5 g/dL Female: 12.0-16.0 g/dL	2.09-2.71 mmol/L 1.86-2.48 mmol/L

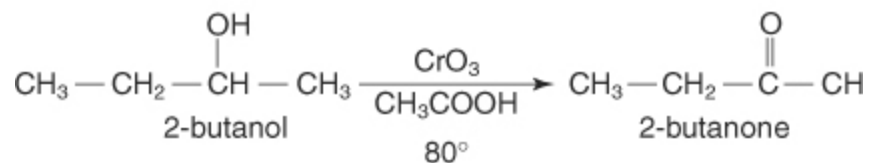
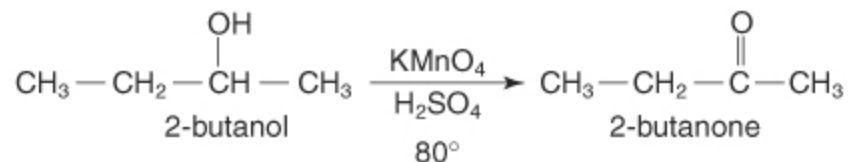
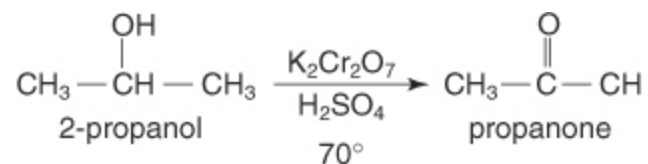
Organic Chemistry and Medicine

Biology



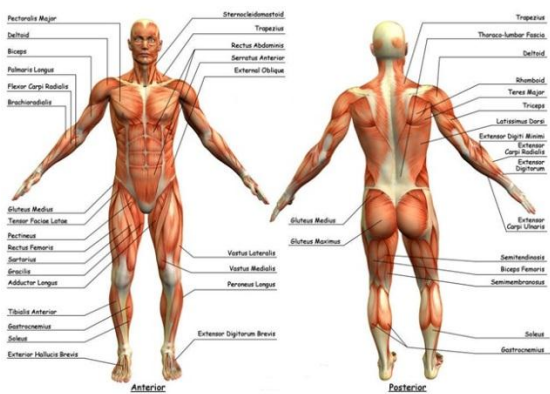
Organic Chemistry and Medicine

Organic Chemistry

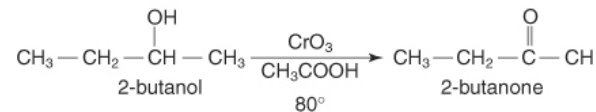
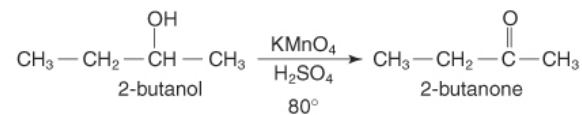
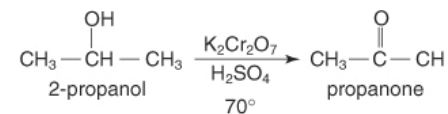


Organic Chemistry and Medicine

Medicine



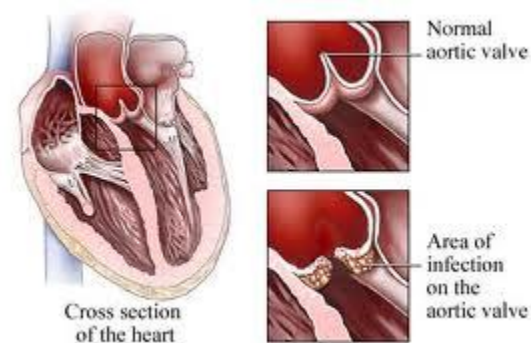
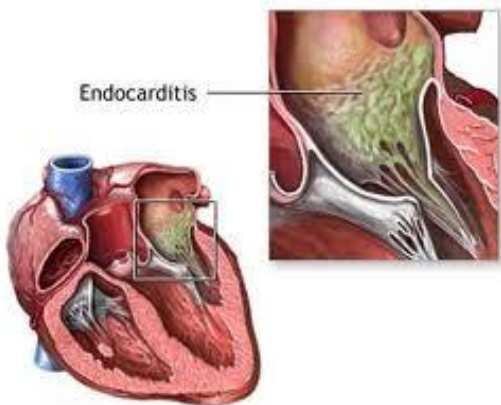
Organic Chemistry



Case 1

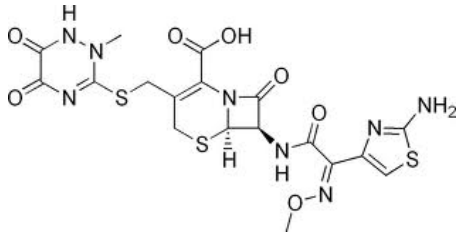
A 30-year-old man is evaluated in the emergency department for complications of difficulty breathing, chills, and chest pain for the past 24 hours. He denies any previous history of medical problems. On physical examination, he appears ill. His temperature is 40°C (104°F), his blood pressure is 90/50 mm Hg, and his heart rate is 110/min. Cardiac examination reveals a 3/6 diastolic murmur; however, the patient denies any history of a murmur. ECG results are normal.

Diagnosis: Acute Endocarditis

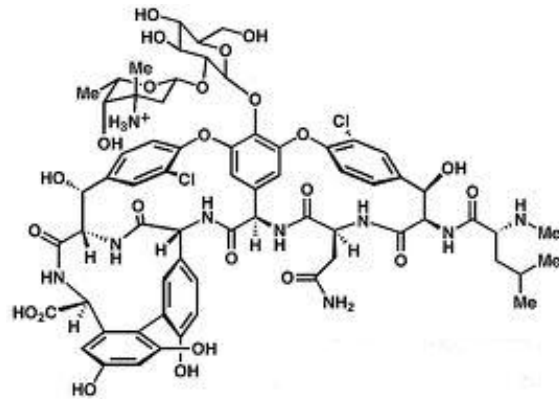


How does this case relate to organic chemistry?

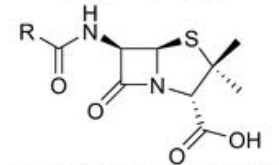
Treatment of Endocarditis



CEFTRIAZONE

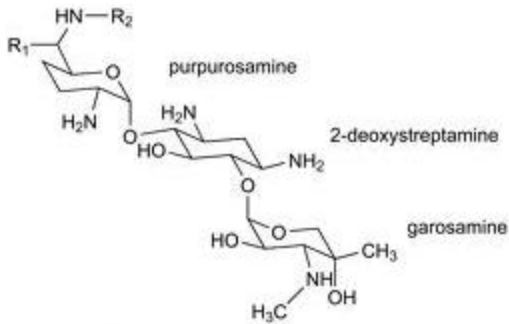


VANCOMYCIN

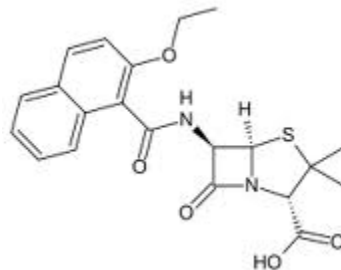


THE MOST WIDELY USED ANTIBIOTIC

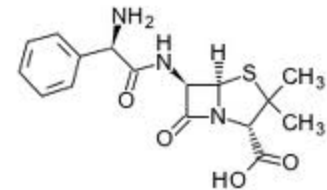
PENICILLIN



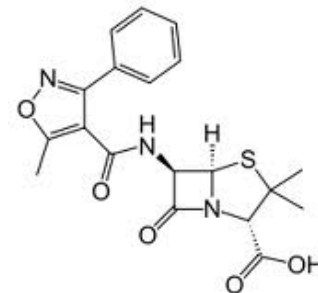
GENTAMICIN



NAFCILLIN

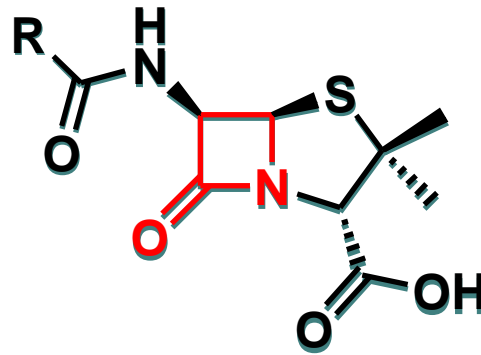


AMPICILLIN



OXACILLIN

Penicillin



β -lactam structure is involved in the mechanism of action

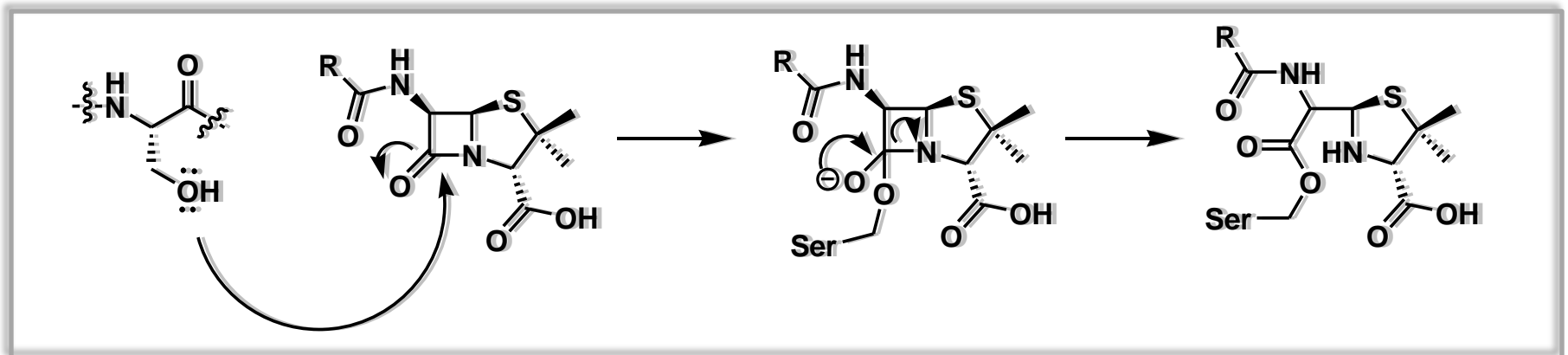
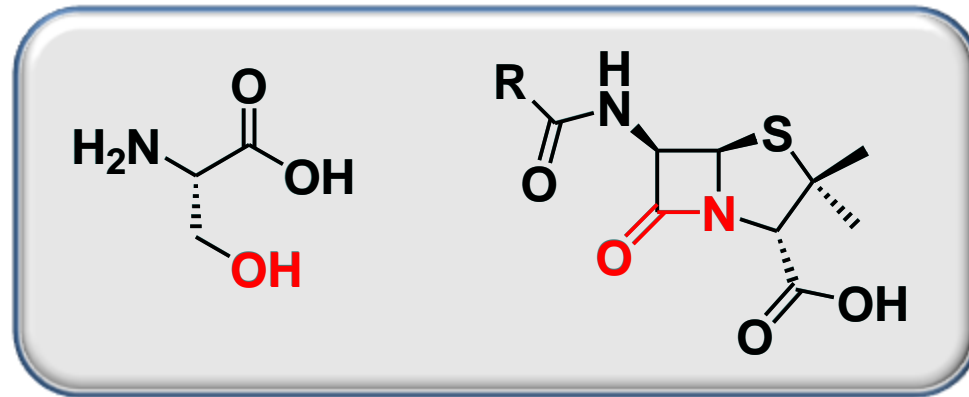
Penicillin Mechanism of Action



Penicillin Binding Protein

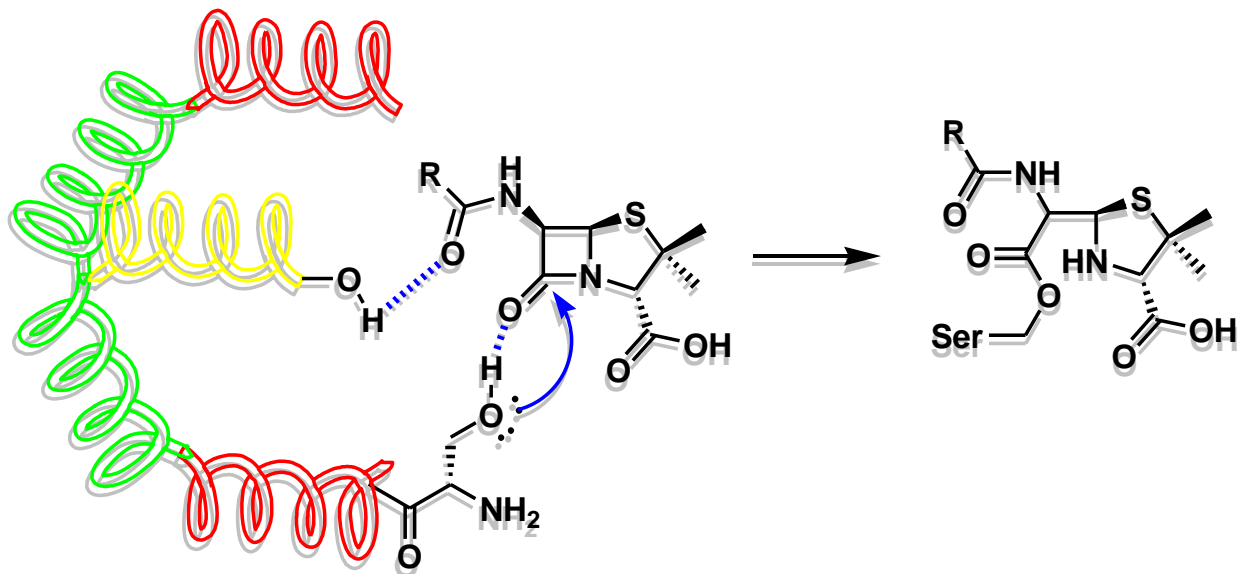
- PBPs are all involved in the final stages of the synthesis of peptidoglycan, which is the major component of bacterial cell walls.
- Bacterial cell wall synthesis is essential to growth, cell division (thus reproduction) and maintaining the cellular structure in bacteria.
- Inhibition of PBPs leads to irregularities in cell wall structure such as elongation, lesions, loss of selective permeability, and eventual cell death and lysis.

Penicillin Mechanism of Action



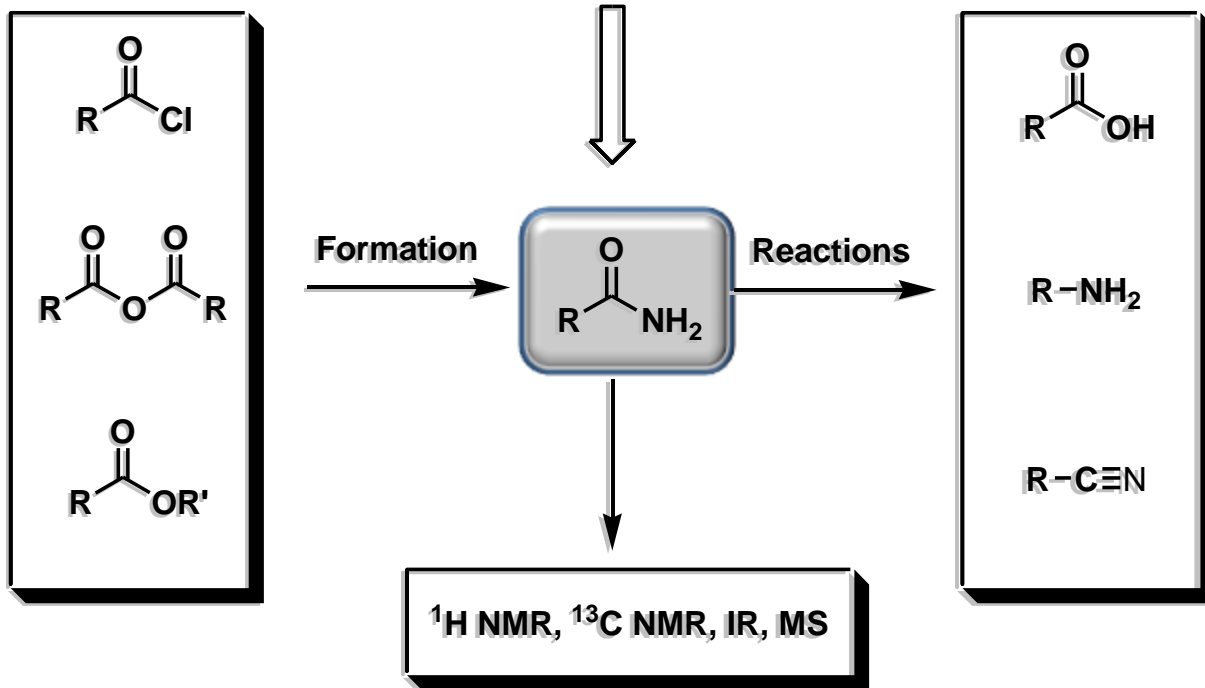
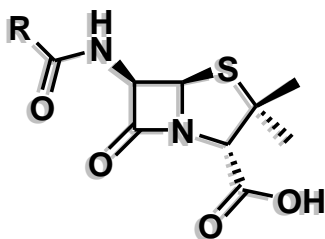
Nucleophilic Attack on the Cyclic Amide Carbonyl Carbon

The Chemistry of Amides

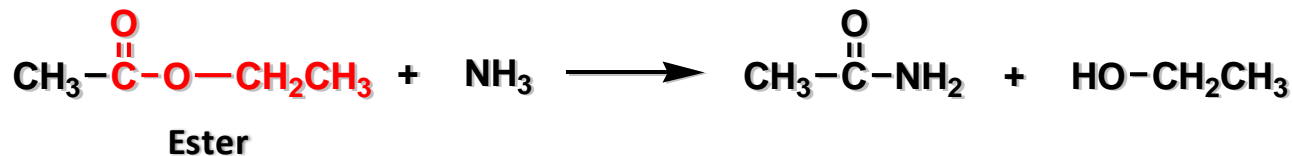
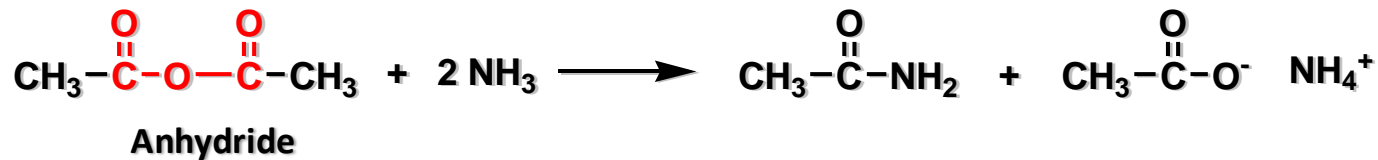
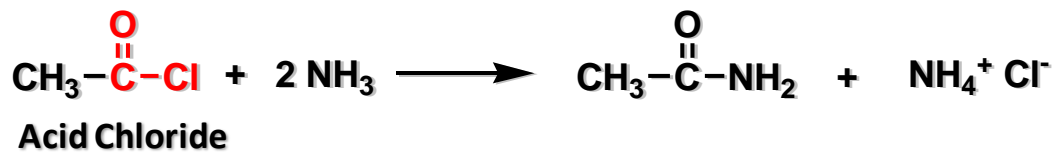
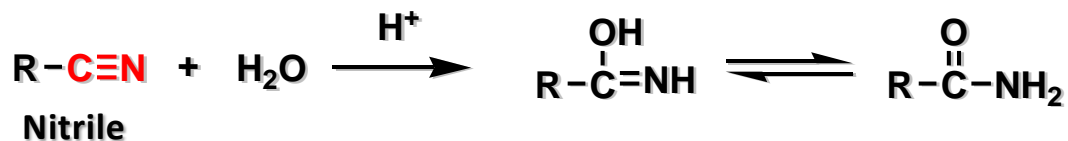


Biology sets the reaction up perfectly; however, this is not the case in a chemistry laboratory....

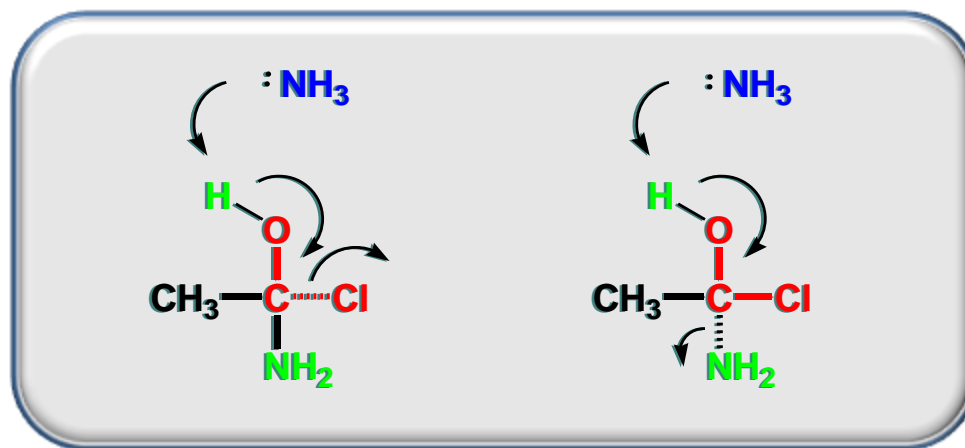
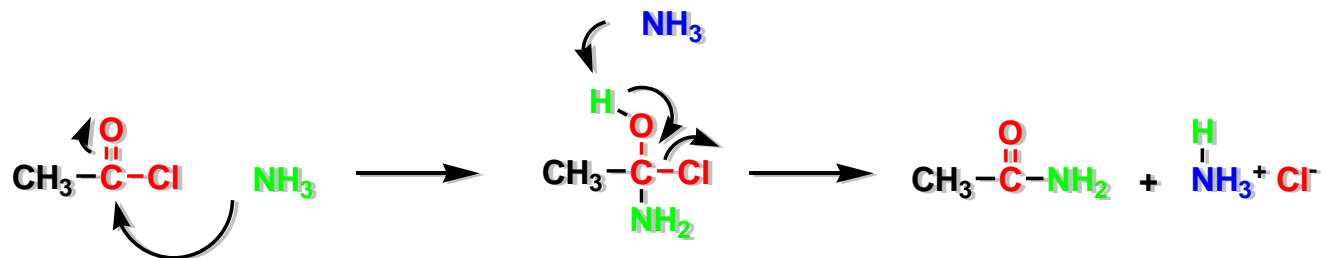
The Chemistry of Amides



The Formation of Amides

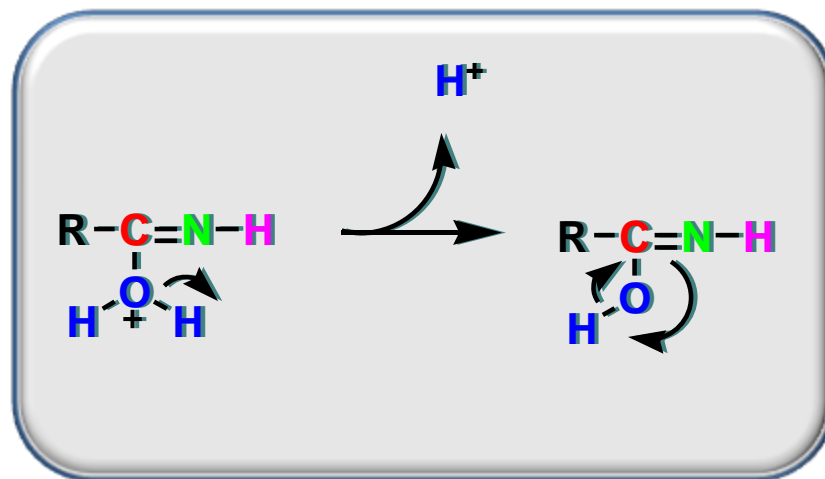
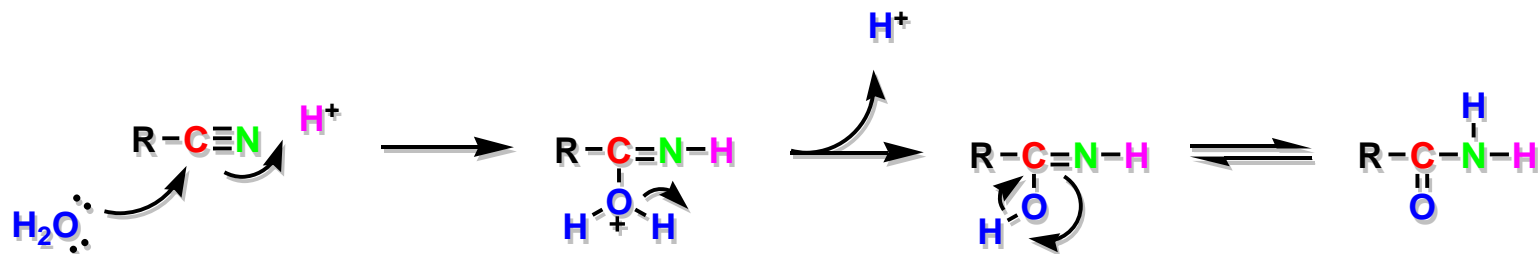


Mechanisms



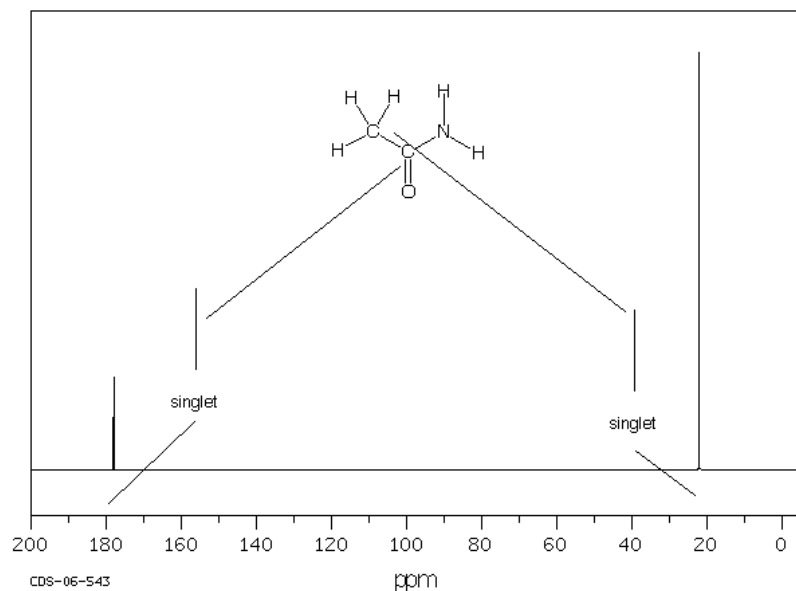
Halides are great leaving groups

Mechanisms



Regenerated acid catalyst

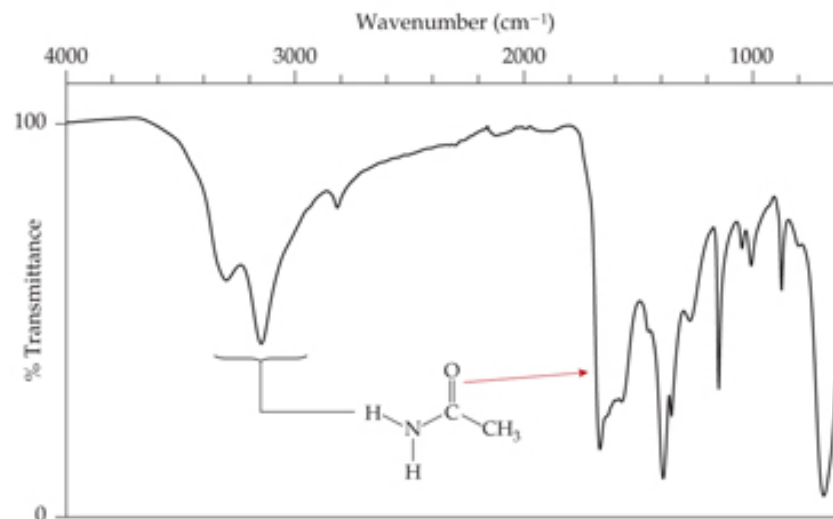
^{13}C NMR and IR of Amide



^{13}C NMR spectra

Carbonyl carbon: 180 ppm

Alkyl carbon: 20 ppm



IR spectra

Carbonyl group: 1700 cm^{-1}

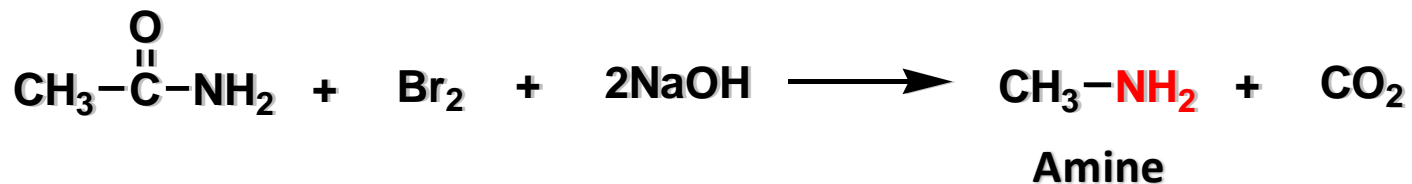
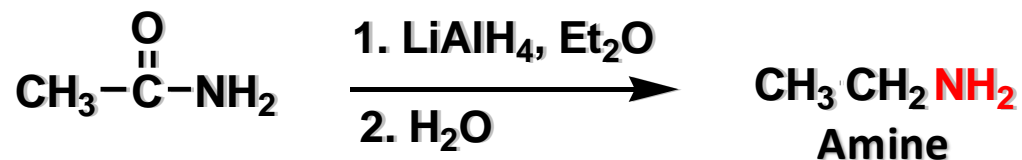
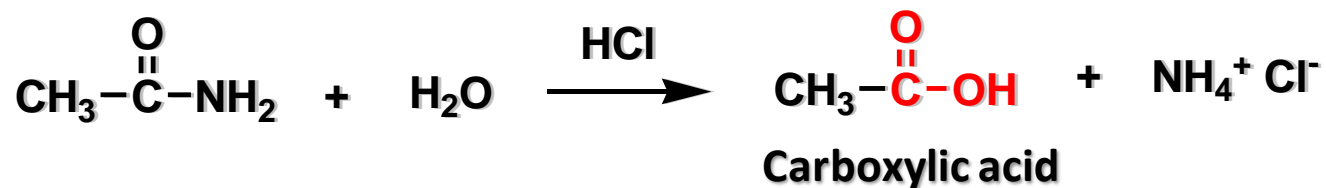
N-H group: 3200 cm^{-1}

- Physicians obtain laboratory values and perform diagnostic tests
- Organic chemists obtain spectroscopic data and perform model reactions

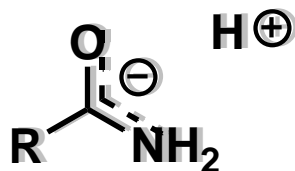
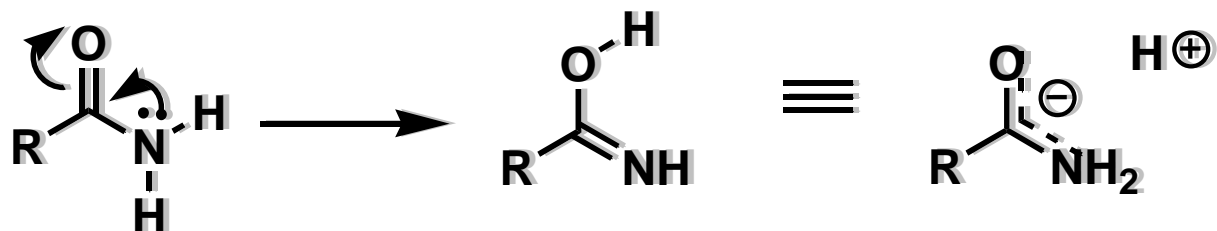
The Chemistry of Amides

**What compounds can we make
from the amide functional group?**

The Chemistry of Amides

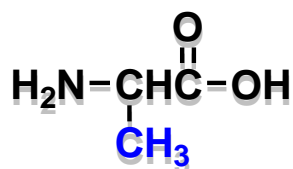
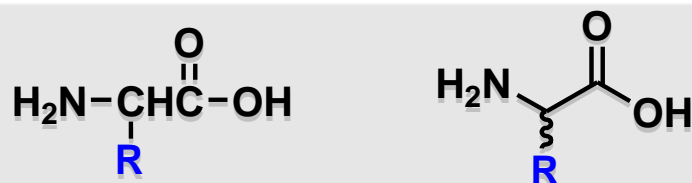


Stability of Amides

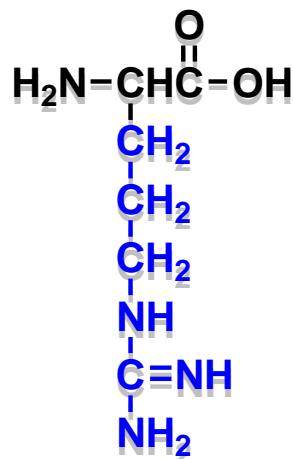


Less electrophilic than other carbonyl functional group

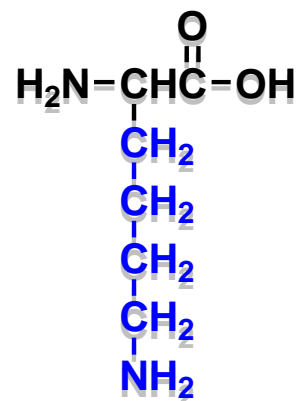
Amides and Amino Acids



Alanine

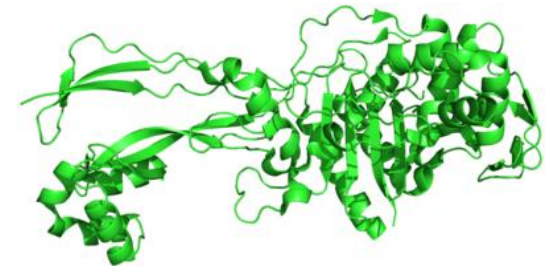
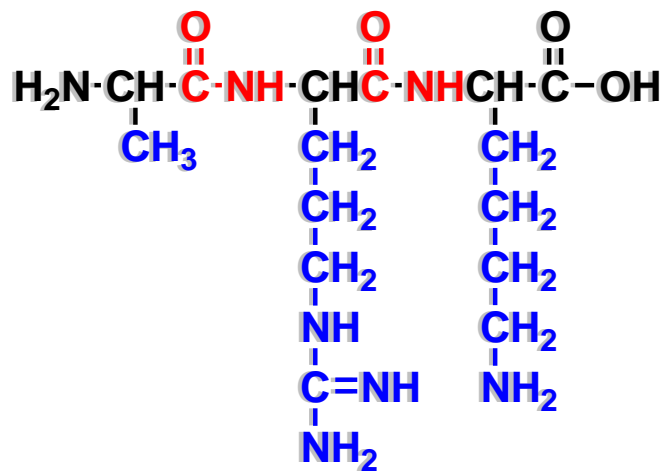


Arginine

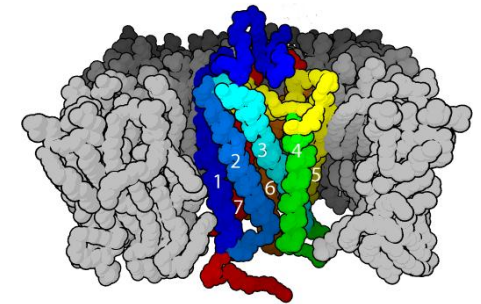


Lysine

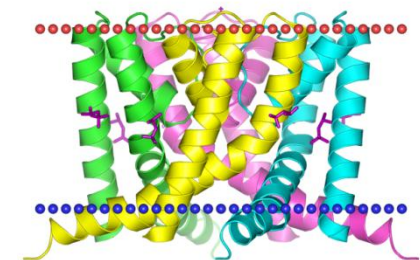
Amides and Amino Acids



Penicillin Binding Protein



G-coupled Protein Receptor



Na/K Channel