The Autonomic Nervous System
Autonomic Nervous System

Functions:
- Without conscious effort, 
- Continuously.

Controls:
- Activities in smooth & cardiac muscles and sweat glands.
Nervous System

Central N.S.
- brain & spinal cord

Afferent Division (information in)

Somatic System (skeletal muscles)

Efferent Division (orders out)

Somatic System
- Sympathetic
- Parasympathetic

Autonomic system
Components of the ANS

The autonomic component is divided anatomically into:

- the nerve fibers that innervate target organs or tissues
- and nerve fibers that innervate the adrenal medulla that causes the release of substances called catecholamines that act upon the ANS.
Autonomic Nervous System

The Autonomic System can be influenced or manipulated in two ways:

- by hormones that are circulated through the blood stream (ie. ADH);
- and by the stimulation or blocking of nerve impulses. An example is the transmission impulses from receptors in the carotid sinus and aortic arch to control B/P.

- Both play important roles in the reflex regulation of the system.
Sympathetic Neurons

- Sympathetic neurons exit the spinal cord via the thoracic vertebrae and lumbar vertebrae. For this reason the sympathetic division is sometimes called the thoracolumbar division.
Sympathetic Division
Parasympathetic Neurons

- The parasympathetic system is also termed the **Cranial-Sacral** system because of the location on the spinal cord that these nerves are located.

- Preganglionic fibres arise from neurons in the midbrain – medulla & pons – and the sacral area of the spinal cord.

- The Vagus (X) nerve carries about \( \frac{3}{4} \) of all Parasympathetic fibres.
Parasympathetic Division
Anatomy

- Sympathetic
  - “thoracolumbar”
  - T1-L3 (F, F, F)

- Parasympathetic
  - “craniosacral”
  - brainstem &
  - S2-S4 (R & D)
# Actions: Sympathetic vs. Parasympathetic

<table>
<thead>
<tr>
<th>Site</th>
<th>Sympathetic</th>
<th>Parasympathetic</th>
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</thead>
<tbody>
<tr>
<td>Eye</td>
<td>Dilate</td>
<td>Constrict</td>
</tr>
<tr>
<td>Trachea/ Bronchi</td>
<td>Dilate</td>
<td>Constrict, increase secretions</td>
</tr>
<tr>
<td>Heart</td>
<td>Increase HR, contractility</td>
<td>Decrease rate, contractility</td>
</tr>
<tr>
<td>GI Tract</td>
<td>Decrease GI Motility</td>
<td>Increase Motility</td>
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<tr>
<td>Blood Supply to Muscles</td>
<td>Increased</td>
<td>No effect</td>
</tr>
<tr>
<td>Blood Supply to Skin/Mucous Membrane/GI Tract</td>
<td>Constrict</td>
<td>No effect</td>
</tr>
</tbody>
</table>
Exceptions

- All systems dual innervation (both sympathetic and parasympathetic fibres).

- Exceptions:
  - Adrenal medulla
  - Sweat glands and piloerector muscles
  - Ventricles of Heart
  - ALL ARE SYMPATHETIC INNERVATION ONLY
Structure of a typical neuron
Axon End Terminal; Meet Dendrite
Actual Photograph
Two of the most frequently discussed neurotransmitters:

- **Epinephrine and Norepinephrine**
  - binds to:
    - alpha ($\alpha_1 \alpha_2$)
    - beta ($\beta_1 \beta_2$)-note NE binds B1 only

- **Acetylcholine**
  - nicotinic
  - muscarinic
Other Neurotransmitters

- serotonin (5-HT)
- melatonin
- Glutamate
- gamma aminobutyric acid (GABA), aspartate
- glycine
- histamine
- Adenosine, ATP, GTP, and their derivatives
Neurotransmitters send chemical messages.
Norepinephrine

- The major postganglionic neurotransmitter of the SNS.
- It is produced from building blocks that are present in the end terminal of the neuron.
1. **SYNTHESIS OF NOREPINEPHRINE**
   - Hydroxylation of tyrosine is the rate-limiting step.

2. **UPTAKE INTO STORAGE VESICLES**
   - Dopamine enters vesicle and is converted to norepinephrine.
   - Norepinephrine is protected from degradation in vesicle.
   - Transport into vesicle is inhibited by reserpine.

3. **RELEASE OF NEUROTRANSMITTER**
   - Influx of calcium causes fusion of vesicle with cell membrane.
   - Release blocked by guanethidine and bretylium.

4. **BINDING TO RECEPTOR**
   - Postsynaptic receptor activated by binding of neurotransmitter.

5. **REMOVAL OF NOREPINEPHRINE**
   - Released norepinephrine is rapidly taken into neuron.
   - Uptake is inhibited by cocaine and imipramine.

6. **METABOLISM**
   - Norepinephrine is methylated by COMT and oxidized by monoamine oxidase.

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**Adrenal medulla:**
80% NE → EPI
Storage and Release

- Neurotransmitters are taken up for storage at terminal endings of nerves.
- Nerve impulse prompts exocytosis of vesicles containing neurotransmitter.
Exocytosis
Exocytosis

Exocytosis is the process by which small vesicles are released from the cell membrane. This process is mediated by specialized proteins that interact with the vesicle membrane and the cell membrane to facilitate fusion. The vesicles contain various substances, such as neurotransmitters, hormones, or digestive enzymes, that are released into the extracellular space upon exocytosis. The Golgi apparatus, the endoplasmic reticulum, and lysosomes are involved in the synthesis and maturation of these vesicles. The vesicle incorporates into the cell membrane, and the contents are released outside the cell.
Norepinephrine

Following its use as a neurotransmitter, Norepinephrine is removed by:

- Reuptake into the terminal nerve ending by active transport – 50-80%.
  - Na+,K+-ATPase is the pump responsible for this reuptake.
  - Pump inhibited by cocaine, TCAs.

- Diffusion away from the nerve endings into the surrounding body fluids.

- Destruction by enzymes such as MAO & COMT.
Synthesis of Acetylcholine

- Acetylcholine is the major preganglionic neurotransmitter of both the SNS and PNS and is the neurotransmitter of the postganglionic side of the PNS.
- It is also the neurotransmitter for the somatic system with striated skeletal muscle.
- The only exception to this is the neurotransmitter for the pilomotor and sweat glands innervated by the SNS. Acetylcholine is the neurotransmitter responsible at this end also, not Norepinephrine. This distinction is important when you start to study toxidromes.
Synthesis of Acetylcholine

- The process of synthesizing acetylcholine requires a catalyst to enable the reaction to occur.
- This enzyme is choline acetyltransferase.
- On the opposite end, when acetylcholine is broken down, it requires cholinesterase to facilitate the process.
- Acetyl coenzyme A binds with choline in the presence of catalyst choline acetyltransferase to form acetylcholine.
- Acetylcholine is broken-down by cholinesterase.
1. **Synthesis of Acetylcholine**
   - Transport of choline inhibited by hemicholinium

2. **Uptake into Storage Vesicles**
   - Acetylcholine protected from degradation in vesicle

3. **Release of Neurotransmitter**
   - Release blocked by botulinum toxin
   - Spider venom causes release of acetylcholine

4. **Binding to Receptor**
   - Postsynaptic receptor activated by binding of neurotransmitter

5. **Degradation of Acetylcholine**
   - Acetylcholine is rapidly hydrolyzed by cholinesterase in the synaptic cleft

6. **Recycling of Choline**
   - Choline is taken up by neuron

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**INTRACELLULAR RESPONSE**
ANS Receptors

- The parasympathetic system is referred to as the cholinergic system - this is because the major neurotransmitter for the PNS is acetylcholine.
- So why is the sympathetic system called the adrenergic system?

*There are two major receptors in the PNS:*
ANS Receptors

- **Muscarinic** which are in the postganglionic PNS on the target end organs.

- **Nicotinic**, which are in the preganglionic side of both the SNS and the PNS.

- Some of the drugs that we administer affect these receptors specifically: atropine blocks muscarinic receptors specifically and other agents (curare) block nicotinic receptors in skeletal muscle.
**Receptors ( I )**

- **Adrenergic ( SNS ):**
  - $\alpha_1$
    - blood vessels
      - constriction
  - $\alpha_2$
  - $\beta_1$
    - heart
      - ↑ HR, contractility, & conduction
  - $\beta_2$
    - bronchial/vascular s.m.
      - dilation

- **Cholinergic ( PNS ):**
  - **Muscarinic:**
    - end-organs
      - ( Parasympathetic )
    - stimulate accordingly

- **Nicotinic:**
  - ganglia
    - stimulate post-ganglion neuron
  - muscles
    - stimulate contraction
alpha (\( \alpha \)) and beta (\( \beta \)) Receptors:

*Alpha Receptors*

- **Alpha 1 receptors:**
  - Found predominately outside of the heart & major organs.
  - Influence smooth muscle found in the peripheral vasculature, intestinal tract and eyes.

- **Alpha 1:**
  - Vasoconstriction, pupil dilation, intestinal relaxation, etc.
Alpha Receptors

Alpha 2 receptors:
- Act as a mediator of neurotransmitter production – as neurotransmitter is released from the neuron, receptor sites on the neuron become filled – when sufficient numbers have been occupied, a message is sent to reduce or turn-off the production of neurotransmitter – this is sometimes referred to as a feedback loop mechanism.

Alpha 2:
- Preganglionic receptor that regulates the release of neurotransmitter through a feedback loop.
Beta Receptors

**Beta Receptors**

- **Beta 1 receptors:**
  - Found in the heart – stimulation or excitement of these receptors leads to an increase in heart rate (chronotropic), in force of contraction (inotropic), and rate of nerve impulse conduction (dromotropic).
alpha (α) and beta (β)

Receptors: 

**Beta 2 receptors:**
- Found primarily in the pulmonary smooth muscle lining the lower airways of the lungs and in the peripheral vasculature – it is also thought that beta 2 cells in the liver regulate the release of glycogen stores.

**Beta 2:**
- Primarily bronchodilation and peripheral vasodilation with increased glycogen release.

IF you have trouble remembering where the beta 1 and beta 2 receptors are located,
- then just think of 1 heart = beta 1; and 2 lungs = beta 2.
Before We Continue

**AUTONOMIC**

- **Sympathetic innervation of adrenal medulla**
  - Preganglionic neuron
  - Acetylcholine
  - Nicotinic receptor
  - Adrenal medulla
  - Epinephrine released into the blood
  - Adrenergic receptor
  - Effector organs

- **Sympathetic**
  - Acetylcholine
  - Nicotinic receptor
  - Norepinephrine
  - Adrenergic receptor

- **Parasympathetic**
  - Acetylcholine
  - Nicotinic receptor
  - Muscarinic receptor

**SOMATIC**

- no ganglia
- Acetylcholine
- Striated muscle

**Neuroeffector transmitter**
Pharmacology of Synaptic Transmission

- Drugs that facilitate a neurotransmitter’s effects are called **agonists**; drugs that reduce a neurotransmitter’s effect are called **antagonists**

- Drugs act upon one or more of the steps in neurotransmitter action; the exact mechanism varies from drug to drug
Pharmacology of Synaptic Transmission

- For example, **cocaine** is a catecholamine agonist that acts by blocking the reuptake of dopamine and norepinephrine.
Pharmacology of Synaptic Transmission

- By contrast, **valium** is a GABA agonist that acts by increasing the binding of GABA to its receptor

  - GABA is an inhibitory neurotransmitter (it’s receptor allows Cl- in, hyperpolarizing, IPSPs)
Pharmacology of Synaptic Transmission

- **Atropine** and **curare** are both ACh antagonists;
  - atropine blocks muscarine receptors, not allowing acetylcholine to bind
  - whereas curare paralyzes by blocking nicotinic receptors, not allowing acetylcholine to bind
Toxicology
Definitions

- **Toxidrome**: a set of signs and symptoms induced by ingestion of a toxic substance.
- **Toxicology**: The science of poisons, including their source, chemical composition, action, tests, and antidotes.
- **Toxicodynamics**: the study of the effects of the toxic substance at the molecular level.
Major Toxic Syndromes

- Cholinergic/Anticholinesterase
- Anticholinergic
- Hallucinogenic
- Opiate
- Sedative/hypnotic
- Sympathomimetic
- Drug Withdrawal
Cholinergic & Anticholinesterase

- Organophosphate insecticides are examples of cholinesterase inhibitors.

- Muscarinic signs and symptoms may be remembered by using one of the following mnemonics:
  
  DUMBBELS  SLUDGE
Cholinergic & Anticholinesterase

- Diarrhea
- Urination
- Miosis
- Bronchorrhea
- Bradycardia
- Emesis
- Lacrimation
- Salivation

- Salivation
- Lacrimation
- Urination
- Defecation
- G.I. Cramps
- Emesis
Cholinergic & Anticholinesterase

- Nicotinic signs can be remembered using the **MTWHF** mnemonic:
  - Mydriasis
  - Tachycardia
  - Weakness
  - Hypertension/Hypoglycemia
  - Fasiculations
Cholinergic & Anticholinesterase

- Central signs may include:
  - Confusion
  - Convulsions
  - Coma
Anticholinergics

- TCA
- Antihistamines
  - Belladonna alkaloids
    (atropine/scopolamine)
- Mushrooms
- Antipsychotics
- OTC sleep meds.
- OTC cold meds.
- Scopolamine
- Jimson Weed
Red As A Beet
Hot as a Hare
Mad as A Hatter
Dry as a Bone
Blind as a Bat
Anticholinergics

Signs include:

- **Peripheral:**
  - flushed skin
  - mydriasis
  - hyperpyrexia
  - dry skin & mucous membranes
  - thirst
  - urinary retention

- **Central:**
  - anxiety, confusion
  - agitation
  - dysphagia
  - delirium
  - ataxia
  - lethargy
  - respiratory failure
  - coma, death
Anticholinergics

Vital signs:

- *Increased pulse, increased respiratory rate, increased B/P, increased temp.*

- These patients have many of the same signs as seen in sympathomimetic & withdrawal.

- It is useful to note that these patients don’t sweat or have bowel sounds.
Sympathomimetics

- Cocaine
- Methamphetamine
- Methylphenidate (Ritalin)
Sympathomimetics

- Hypertension
- Tachycardia
- Psychomotor Agitation
- Hyperthermia
- Diaphoresis
- Mydriasis
Causes of Adrenergic State

Think I’m not *SAD*

- Sympathomimetics
- Anticholinergics
- Drug withdrawal
- Hallucinogens
Opiates

- Miosis
- Respiratory depression
- Bradycardia
- Hypotension
- Sedation
- Decreased GI motility
- Hypothermia
- Pulmonary edema
- Seizures
Narcotics

- **Narcotics:**
  - Heroin, Morphine, Codeine, Meperidine

- **Signs may include:**
  - CNS depression
  - Respiratory depression
  - Pulmonary edema
  - Hypotension
  - Miosis (except Demerol)
  - Seizures
Narcotics

- Miosis seen in approximately 90% of Narcotic O.D., unless hypoxic or mixed overdose (exceptions are Demerol and Talwin).

- If vomiting occurs with these patients, good chance of aspiration.

- Non-cardiogenic pulmonary edema can be an extremely rapid onset, is usually fulminating.

- Longer half/life than narcan
Barbituates

- **Barbituates:**
  - *Phenobarbital*: Long lasting
  - *Butabarbital*: Intermediate
  - *Secobarbital*: Short acting

**Overdose:**

- **No antidote**
- *Skin bullae presentation*
Narcotic Overdose: Special cases

- Pupils large
  - Meperedine (Demerol)
  - Lomotil
- Narcan may not work:
  - Fentanyl
    - Rigid chest syndrome
  - Long acting agents
    - methadone
    - MS-Contin
    - Oxycontin
Narcotic Overdose: Atypical toxicity seen

- **Seizures**
  - Meperedine (Demerol)
  - Tramadol (Ultram)
  - Pentazocine (Talwin)
  - Proxyphene (Darvocet)

- **Ventricular arrythmias**
  - Proxyphene (Darvocet)

- **Serotonin syndrome**
  - Meperedine
  - Dextromorphan
Narcotic Withdrawal

Vital Signs:

- *Increased respiratory rate, increased pulse, increased B/P, increased temp.*

Signs may include:

- Agitation
- Yawn
- Vomiting
- Cold turkey skin
- Normal mental status
Narcotic Withdrawal

Cholinergic ++

Progression of signs & symptoms:

- Yawn, lacrimation, rhinnorhea, diaphoretic, restless, insomnia.
- Mydriasis, goosebumps, aching, nausea.
- Anorexia, vomiting, diarrhea, (after 2-3 days).
- Dishevelled appearance, fever, increased B/P.
Toxins and their Antidotes

Acetaminophen → N-acetylcysteine

Anticholinergics → Physostigmine

Anticholinesterases/Cholinergics → Atropine
  (muscarinic effects)

Cholinergics → Pralidoxime
  (nicotinic effects)
Toxins and their Antidotes

- Benzodiazepines → Flumazenil
- Botulism → Botulinum antitoxin
- Beta-blockers → Glucagon
- Calcium channel blockers → Calcium
- Carbon monoxide → Hyperbaric O₂, O₂
- Cyanide, Nitrites → Sodium thiosulfate
Toxins and their Antidotes

- Warfarin → Vitamin K
- Methanol → Ethanol
- Methemoglobin → Methylene blue
- Opioids → Naloxone
- Tricyclic antidepressants → NaHCO3
Pupillary Reactions

Drugs that can cause Miosis:

- Narcotics (except Demerol)
- Cholinergic & Anticholinesterase Organophosphates
- Phencyclidine (PCP)
- Mushrooms
- Phenothiazines

Drugs that can cause Mydriasis:

- Anticholinergics
- Sympathomimetics
- Drug withdrawal
- Demerol
- Cholinergic & Anticholinesterase
Drugs that can cause Pulmonary Edema

- Drugs that cause pulmonary edema:
  - Salicylates
  - Narcotics (especially Heroin)
  - Carbon monoxide
  - Sedative - hypnotics
  - Organophosphates
Toxidromes

If patient presents with:
- pinpoint pupils
- CNS depression
- respiratory depression

*Think Narcotics*

If patient presents with:
- dilated pupils
- dry skin
- decreased GI motility
- dysrhythmias
- ↑ respirations, pulse, B/P, temperature

*Think Anticholinergic Syndrome*
Toxidromes

If patient presents with:

- pinpoint pupils
- sweating
- increased secretions - SLUDGE
- increased GI motility

*Think Cholinergic Syndrome*
Toxidromes

If patient presents with:

- pallor
- diaphoresis
- nausea / vomiting / diarrhea
- hyperadrenergic (SNS)
  - ↑ respirations, pulse, B/P, temperature
- bowel sounds present

Think

Sympathomimetic / Drug Withdrawal
ecstasy

mdma
3,4
Methylenedioxymethamphetamine
Overview

- Stimulant/hallucinogen
- 1950’s-army
- 1970’s therapy tool
- Route of admin.
Dose

- 50-100mg/tablet
- Effective dose is 1-2mg/kg
- Onset 30-60 min.
- Effects last 3-4 hours
Effects of Ecstasy

- Tachycardia
- Mydriasis
- Hypertension
- Hyperthermia

- Muscle Cramps
- Hallucinations
- Sweating
- Dehydration
But Wait, There’s More

- Rhabdomyolysis
- Cardiac Arrhythmias
- CVAs
- Seizures
- Coma
- Death
Ecstasy destroys neurons.
Treatment Pearls

- C-spine
- ABCs
- Benzodiazepines
- IV fluids
- Cooling
- Cause of most fatalities?
Physiology of Ecstasy
End Terminal and Vesicles
Receptors & Re-uptake

- = serotonin molecule
- = reuptake transporter
- = other receptor

axon terminal

dendrite
Serootonin/Receptor Binding
Gimme an “E!”
Serotonin Reuptake Transporters
Monoamine Oxidase
Don’t Bring Me Down
Depressed? You Bet!
Funny, I crave turkey

5-htp + decarboxylase = serotonin (5-HT)
Receptor Down-regulation
Neurotoxicity - Current Theory

MAO breaks down the dopamine into toxic metabolites.

Dopamine enters by mistake

Empty
Shrinkage

Degenerated serotonin axon terminal

dendrite
How Ecstasy Works
Transporter Working Backwards
End Result
Ecstasy + Prozac = Nothing!
Timeline

- 3000 BC - Coca chewing practiced in S. America
- 1500s Incan coca plantations controlled by Spanish
- 1575 - Labourers in Spanish silver mines chewed coca
- 1855 - Cocaine extracted from coca leaves
- 1862 - Merck produces ¼ pound of cocaine
- 1884 - Freud advocates use to treat variety of conditions
- 1884 - Merck produces 3179 pounds of cocaine
- 1886 - Merck produces 158352 pounds
Timeline

- 1886 Coca Cola introduced
- 1901 Coca Cola removes coca from their formula
- 1910 First reports of nasal damage in literature
- 1912 US government reports 5000 cocaine related fatalities/year
- The Harrison Narcotics Act of 1914 banned nonprescription use of cocaine-containing products
- 1920-1970 cocaine use diminishes
- 1970 Cocaine becomes schedule II substance
- 1984 One kg costs $25000
Norepinephrine Everywhere!

- 25-100mg/line
- Coca-Cola had 80mg/bottle
Cocaine Effects

- Think hyperadrenergic
- Blocks reuptake of norepinephrine
- Stimulates release of norepinephrine, dopamine and serotonin
Side Effects

- CVA
- Hyperthermia
- rhabdomyolysis
- MI
- CAD
- Tachycardia
<table>
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<tr>
<th>Route</th>
<th>Onset</th>
<th>Peak Effect (min)</th>
<th>Duration (min)</th>
<th>Half-Life (min)</th>
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<tr>
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<td>3-5</td>
<td>20-30</td>
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<td>3 min</td>
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<td>45-90</td>
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<tr>
<td>Oral</td>
<td>10 min</td>
<td>60</td>
<td>60</td>
<td>60-90</td>
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plus
Methamphetamine
Methamphetamine-An Overview

- First synthesized 1887
- Initial application 1920s as nasal decongestant (Benzedrine)
- WW II used as stimulant
- Popular with students and truckers in the 1950’s (Dexedrine)
- Schedule II in 1971
- Off-white/pinkish or yellowish powder, 5-20% purity
Methamphetamine-An Overview

- Stimulant
- Effects last up to 12 hours (cocaine 20 min)
- Ice, crystal meth (ephedrine reduction) Average dose 50 – 200 mg
- Onset of action
  - Oral: 30-60 min
  - Nasal: 15-20 min
  - Inhaled or injected: 1-3 min
- Elimination half-life and duration of action: 4 – 6 hours
- White, yellow, light brown, dark brown powder
- Whiter is cleaner
- Pills, capsules, injected, smoked
Methamphetamine Users
Tweakers

- Long time, habitual meth users
- Attempt to maintain steady state of meth in their bloodstream
- May be sleep deprived
- Frustrated, unpredictable and dangerous
- May appear “super-exaggerated normal”
Tweakers

- Eyes clear, speech concise, movements brisk
- Eyes look normal but on close exam may be moving 10X faster than normal may appear to roll
- Movements may be exaggerated (overstimulated)
- Thought process scattered, paranoid
- Requires little provocation to react violently, may be hallucinating
Items Found in Labs

- Lab glassware
- Heat source
- Red phosphorus- striker plates/road flares
- Starter fluid (ether)
- Muriatic/hydrochloric acid-hardware stores
- Sodium hydroxide (lye): "Drano"
- Sulfuric acid: battery acid or drain cleaners
- Anhydrous ammonia-farmer’s co-op
- Coleman fuel
- Other solvents and containers
- Toluene: paint thinner
- Methanol: gas tank anti-freeze
- Iodine crystals
- Lithium: camera batteries
Methamphetamine Production
Cold Method

- ephedrine (sudafed)
- Mix with water, denatured alcohol, methanol or other solvent.
- Add iodine, red phosphorus (phogene gas) and water, heat to boiling 6-8 hours
- red phosphorus, lye
- ether, toluene or Coleman fuel.
Cold Method
Nazi Method

- Heat the ephedrine/pseudoephedrine mixture in a dish on a heat source.
- Explosion risk
- sodium metal, lithium wire
- anhydrous ammonia
Signs of Usage

- Think hyperadrenergic!
- Bradycardia?
- Atherosclerosis
- Seizures
- Hyperthermia
Long Term Usage

- Depletion in the neurons of these neurotransmitters, especially dopamine, can have permanent effects in the brain
  - Slowness
  - Parkinson’s like movement disorders- tremor and rigidity
  - Thinking problems
Treatment Pearls

- Benzodiazepines
- Placental vasoconstriction
- Cooling techniques
- Decrease BP = Decrease ICP
History

- 1960’s anaesthetic-issues
- 1980’s bodybuilding-issues
- 1990’s raves-issues
How it Works

- Naturally occurring
- GABA in brain
- Dopamine response - dose dependant
- Hgh in rats
Dose Dependant Effects

- 10mg/kg - amnesia, drowsiness
- 20mg/kg - sleep, delta waves
- 50-70mg/kg - hypnosis, coma
- Note: no analgesia or muscle relaxation
Treatment Pearls

- Manage airway appropriately
- Narcan?
- Bradycardia
- Hypotension
- Watch for myoclonus
Hallucinogens
Mescaline
DISSOCIATIVE DRUGS

Ketamine
Phenycyclidine (PCP)
Phenylcyclohexylpyrrolidine (PHP)

Acts on all six neurotransmitter systems

*Anticholinergic*: dry skin, miosis
*Dopaminergic/Adrenergic*: agitation, delusions
*Opioid*: pain perception alterations
*Serotoninergic*: perceptual changes
*GABA receptor inhibition*: excitation
Treatment

- Haloperidol
  - Presynaptic dopamine antagonist
  - Shifts the dopamine-acetylcholine activity ratio in the limbic system
  - Therefore can counteract the dopamine stimulation and cholinergic antagonism of the drug
PCP
Usage

- First tried in humans
- Never mind.....what about using it to neuter fluffy?
Actions

- 1-5 minutes for onset
- 30-45 minutes duration of effect
- Provides analgesia and anaesthesia
- K-hole
Treatment Pearls

- Watch the laryngospasm
- Minimize tactile stimulation to diminish psychosis
- Watch for transient spikes in BP
Jimson Weed
Dextromethorphan
NITROUS OXIDE

$N_2O$
Stages of Anaesthesia

- Drowsiness, confusion, analgesia
- Euphoria, excitement, spontaneous muscle movements, hallucinations
- Loss of consciousness
Negative Side Effects

- Frostbite
- Malignant Hyperthermia
- Does not combine with hemoglobin
- Injuries from falling