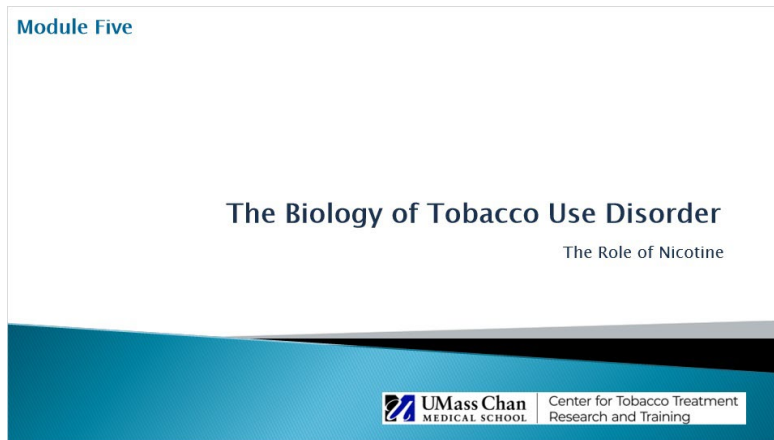
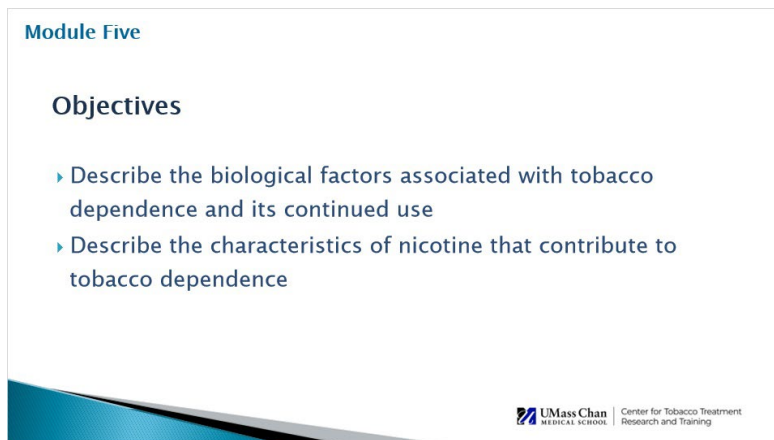


Module 5: The Biology of Tobacco Use Disorder

1.1 The Biology of Tobacco Use Disorder



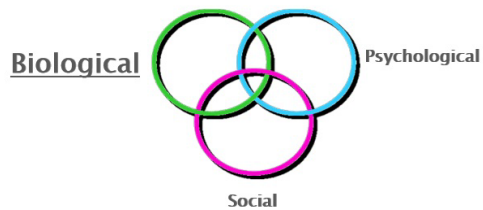
1.2 Objectives



1.3 Biological

Module Five

Tobacco Use Disorder: The Biopsychosocial Model



"Biopsychosocial" recognizes that health is impacted by a complex interaction among the biological, psychological, and social factors

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1.4 Kent

Module Five



Kent

"I have been smoking since I was 20 years old. I really want to quit smoking, but I just can't stop from picking up another cigarette, the urges are just too great and I still can't resist my first cigarette in the morning. I recently tried to quit with the 21 mg patch, but I don't think I was using it correctly and my urges were just too strong."

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1.5 Brainstorm

Module Five



Brainstorm: What are some of the biological factors that affect Kent?

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1.6 Responses

Module Five

Here are some possible responses:



- ❖ Kent's strong urges are due in part to low levels of nicotine in between cigarettes
- ❖ The need for a cigarette first thing in the morning also indicates low levels of nicotine after abstaining overnight
- ❖ Kent recognizes that the 21mg nicotine patch was not replacing all of the nicotine he was getting through smoking cigarettes

1.7 Some key terms to know:

Module Five

Some key terms to know:

- ▶ **Neuron** – an electrically excitable cell that processes and transmits information by electrochemical signaling, via connections with other cells.
- ▶ **Neurotransmitter** – any specific chemical agent released by a neuron to communicate with other neurons.
- ▶ **Nicotinic acetylcholine receptors** – receptors in the body to which nicotine specifically binds.
- ▶ **Sympathetic Nervous System** – controls the body's involuntary response to perceived threats (fight or flight).

1.8 Common neurotransmitters

Module Five

Common neurotransmitters

- ▶ **Dopamine** • creates feelings of pleasure
- ▶ **Acetylcholine** • is linked to both the central nervous system (CNS) and the peripheral nervous system and has many different functions in the brain and muscles
- ▶ **Norepinephrine** • plays a role in the autonomic nervous system, released as part of the 'fight or flight' response increasing heart rate, dilating pupils, increasing blood pressure

1.9 Dopamine is a key neurotransmitter

Module Five

Dopamine is a key neurotransmitter

This brain chemical is involved in many different functions

- ▶ Movement
- ▶ Motivation
- ▶ Reward
- ▶ Dependence



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1.10 Dopamine activates the reward pathway

Module Five

Dopamine activates the reward pathway

Natural rewards are everyday activities that increase dopamine, including:

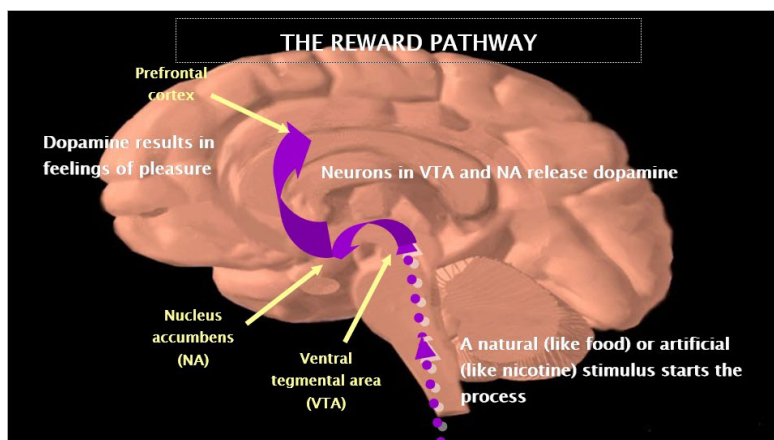
- Food
- Water
- Sex
- Nurturing

Some drugs hijack the system by creating artificially higher levels of dopamine

- Continual use of a drug reduces the ability to experience pleasure
 - From the drug
 - From natural rewards

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1.11 Untitled Slide



1.12 How Nicotine Affects the Brain: Video

Module Five

How Nicotine Affects the Brain: Video

This video gives an overview of nicotine's affect on the brain:



<https://www.youtube.com/watch?v=PqeEGpCQhBA>

Please note: this is a video promoting the quitline in Australia, not the US state quitlines or other national quitlines

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1.13 As described in the video, nicotine's effects include:

Module Five

As described in the video, nicotine's effects include:

- ▶ Activating certain receptors for the neurotransmitter acetylcholine (called nicotinic acetylcholine receptors), which results in the release of neurotransmitters
- ▶ This is the starting point for the drugs behavioral effects:
 - Increased dopamine release may contribute to rewarding and addictive qualities
 - Nicotine also increases acetylcholine release which may contribute to enhanced attention and cognition
 - Increased norepinephrine may contribute to stimulation

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1.14 Repeated nicotine use changes the brain

Module Five

Repeated nicotine use changes the brain

- ▶ When nicotine binds to nicotinic acetylcholine receptors (nAChRs), these receptors are eventually desensitized and become unresponsive
- ▶ The brain compensates by creating more receptors (upregulates the receptors)
- ▶ Tolerance develops – more nicotine is needed for the same effects
- ▶ Periods of abstinence result in withdrawal symptoms
 - After longer abstinence (e.g. sleeping) receptors become responsive again
 - Using more nicotine alleviates cravings and withdrawal symptoms

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1.15 Tolerance contributes to dependence

Module Five

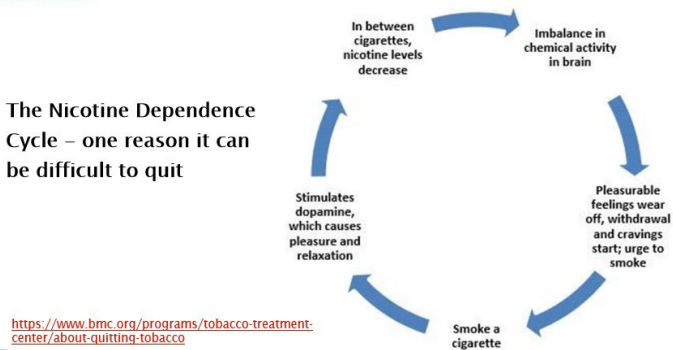
Tolerance contributes to dependence

- ▶ Needing to use more to achieve the desired effects as were achieved previously at lower doses
- ▶ There are diminished effect with continued use of same amount
- ▶ Some factors that influence tolerance:
 - Duration and amount of nicotine exposure
 - Pattern of use
 - Environmental/learned factors
 - Genetics

1.16 Untitled Slide

Module Five

The Nicotine Dependence Cycle – one reason it can be difficult to quit



<https://www.bmc.org/programs/tobacco-treatment-center/about-quitting-tobacco>

1.17 The effects of nicotine on the reward pathway can be overcome by quitting

Module Five

The effects of nicotine on the reward pathway can be overcome by quitting

- ▶ Nicotine hijacks the reward pathway to make us think that we 'need' it for survival
- ▶ Many effects on the brain can be reversed with long-term abstinence from nicotine
- ▶ People who use nicotine and tobacco can be given hope and learn to re-activate the natural reward pathway

1.18 Characteristics of Nicotine

Module Five

Characteristics of Nicotine



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1.19 What is Nicotine?

Module Five

Where is it found?

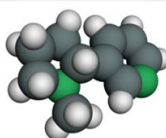
- Virtually all nicotine (including nicotine replacement therapies) is from tobacco plants, although it can be manufactured synthetically
- Also found in tomatoes, potatoes, and eggplant

Chemical structure

- Readily crosses cell membranes (including placental and blood/brain barriers)
- Binds to nicotinic acetylcholine receptors (nAChR) throughout body, primarily in brain and muscle

What is Nicotine?

Nicotine



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1.20 Absorption of nicotine depends on pH

Module Five

Absorption of nicotine depends on pH

pH differs based on the type of tobacco

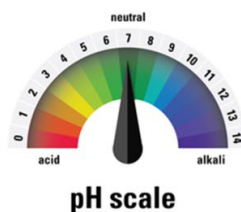
- Spit tobacco, pipe and cigar smoke nicotine is alkaline – ideal for absorption in mouth
- Slower absorption

Cigarette smoke is acidic – ideal for absorption in lungs

- Quicker absorption

pH of vapor from e-cigarettes varies widely

- Likely influenced by flavor additives
- Absorbed in both mouth and lungs



National Academy of Sciences, Engineering and
Medicine, 2018



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1.21 People who are smoking can control nicotine levels

Module Five

People who are smoking can control nicotine levels

- ▶ There is wide variability in the amount of nicotine absorbed among people who use tobacco/nicotine
 - If nicotine level is too low = withdrawal
 - If nicotine level is too high = nausea, palpitations, tremors
- ▶ Personal regulation: “Finger–tip control” of cigarettes
 - Block ventilation holes in filters
 - Smoke more of the cigarette
 - Change the rate and intensity of puffing
- ▶ 1.8 mg of nicotine in most cigarettes



1.22 The Clinical Implications:

Module Five

The Clinical Implications:

- ▶ One cannot rely on the amount of nicotine/tobacco used to determine the degree of dependence. “Light” smokers may be just as dependent.
- ▶ Studies have shown that those who work harder to maintain nicotine levels are more likely to relapse when they try to quit.

1.23 Nicotine from smokeless tobacco (ST) is absorbed more slowly

Module Five

Nicotine from smokeless tobacco (ST) is absorbed more slowly



- ▶ Peak concentration at 30 minutes, absorption for up to 60 minutes after ST is removed
- ▶ Levels of nicotine more consistent than with combustible tobacco
- ▶ Amount of nicotine absorbed depends on:
 - Concentration of nicotine in the ST product
 - Size of the tobacco cuttings (fine cut has more nicotine available)
 - Acidity level of the product (lower acidity=more free nicotine available)
 - 1 can snuff can equal 4 packs cigarettes

1.24 Nicotine content in e-cigarettes varies widely

Module Five

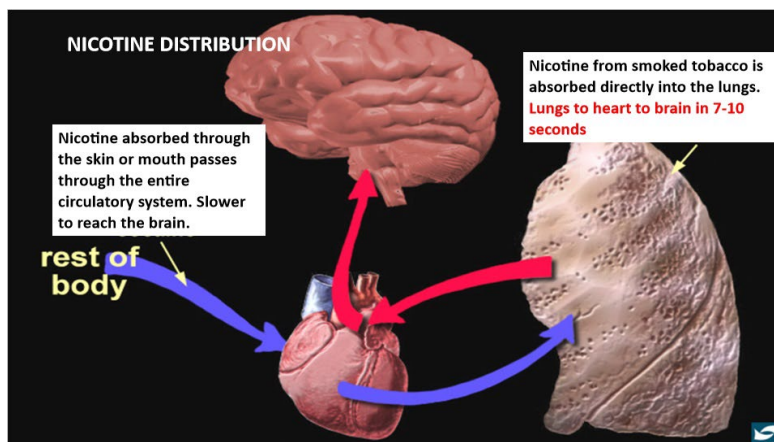
Nicotine content in e-cigarettes varies widely

- ▶ Labeling of nicotine levels is inconsistent e.g.
 - Low, medium, high
 - Amount (mg) per cartridge
 - Percent per cartridge
- ▶ Power of the device impacts delivery of nicotine
- ▶ User behavior, e.g. puff duration, influences absorption
- ▶ Differences in nicotine absorption can vary by more than 50-fold



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1.26 Nicotine affects other systems in the body

Module Five

Nicotine affects other systems in the body

- ↑ Heart rate
- ↑ Blood pressure
- Vasoconstriction
- ↑ Metabolic rate
- Lipolysis
- Skeletal muscle relaxation
- EEG desynchronization

Benowitz, 1992; Benowitz, 2003; Benowitz, 1997; Benowitz, 1988.

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1.27 Nicotine is metabolized quickly

Module Five

Nicotine is metabolized quickly

- ▶ Metabolized to cotinine, primarily in the liver
- ▶ Half-life
 - Nicotine = 2 hours
 - Cotinine = 16 hours
- ▶ Elimination occurs through the kidneys
 - Affected by: renal function, gender, ethnicity and genetics
- ▶ Decrease in metabolism or elimination leads to higher levels for longer periods of time
- ▶ Accumulates in breast milk, detected in blood and urine

Benowitz et al., 1983, 1994, 1996, 1997; Hukkanen, 2005

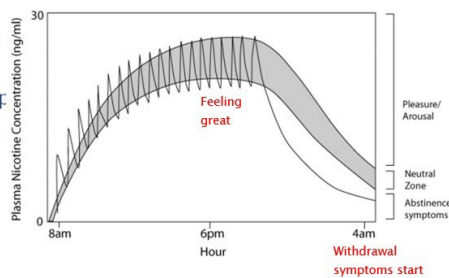
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1.28 People who use tobacco/nicotine work to find their comfort zone

Module Five

People who use tobacco/nicotine work to find their comfort zone

- ▶ Nicotine reaches a plateau after 6–8 hours
- ▶ Rapid drop off during sleep
- ▶ Short half-life drives need for rapid re-dosing
- ▶ Intensity of craving upon waking is a marker of dependence



Benowitz et al., 1983, 1994, 1996, 1997; Hukkanen, 2005

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1.29 Summary – Biological Factors

Module Five

Summary – Biological Factors

- ▶ Nicotine affects brain structure and functions
 - Nicotinic acetylcholine receptors increase causing tolerance
 - Dopamine is an important neurotransmitter in the reward pathway
 - Nicotine and other drugs hijack the reward pathway
- ▶ Smoking delivers nicotine via lungs to brain in 7–10 seconds
- ▶ Other tobacco products delivers nicotine more slowly
- ▶ Nicotine levels fluctuate throughout the day
- ▶ People using tobacco can control the level of nicotine they need

To read more about nicotine and how it works in the body, visit ["How Nicotine Works"](#)

Benowitz et al., 1983, 1994, 1996, 1997; Hukkanen, 2005

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Module Five

Module 5 Required Quiz

To take the quiz, click on the 'course homepage' link below, it will take you to the course main homepage where you can click on the module quiz 'button' to start the quiz.

Course homepage

