A. **Physiology and Drugs: An Overview**

Upon successfully completing this session the participant will be able to:

- Explain in layman’s terms the general concept of human physiology.
- Explain in layman’s terms the purpose and functions of major systems in the body (nervous system, circulatory system, respiratory system, etc.)

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• Explain in layman’s terms how drugs work in the body.
• Explain in general terms how the drug evaluation is used to detect signs or symptoms indicative of drug impairment.
• Correctly answer the “topics for study” questions at the end of this session.

Before we can understand how drugs work, we must have a basic understanding of how the body works.

We will review general concepts of how the body functions in a “normal” or “standard” human.
“Average” or “Normal” Within the DEC Program

- “Average” is a quantity that represents the “middle” or “typical” value that the majority of healthy, non-impaired people would exhibit or have in a specific test that is measured numerically.
- “Normal” describes both a range of values or results that are “close to” average, but can be above or below the “average” value for the majority of healthy non-impaired people. “Normal” can also be used to describe unremarkable conditions on tests that are not measured numerically such as muscle tone, etc.

Within the DEC Program, “normal” means the same thing as “healthy” or “non-impaired” or within the “DRE average ranges.”

For example, the “Average”, or typical value, for pupil size in near total darkness is 6.5 mm. This means that when ALL the sizes were measured using the DRE test protocol, in a large number of pupils in healthy, non-impaired adults, the average pupil size for those was approximately 6.5 mm while the average range, or for normal pupil size was 5.0-8.5 mm.

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Primary focus will be on the systems or component parts of those systems that are examined during the drug influence evaluation.

- Central Nervous System
- Eyes
- Blood Pressure and Pulse
- Balance and Coordination
- Body Temperature

**B. Body Systems**

Physiology is the branch of biology that deals with the functions and activities of life or living matter and the physical and chemical phenomena involved.

For the purposes of this course, physiology is the study of the functions of living organisms and their parts.

*Source: Merriam-Webster’s Medical Dictionary (2008).*
A convenient way of discussing human physiology is to list the ten major systems of the body.

The phrase “MURDERS INC” helps us remember the names of the ten systems.

Each letter stands for the name of one system.
The Ten Systems of Human Physiology: **MURDERS, INC.**

M is for Muscular System  
U is for Urinary System  
R is for Respiratory System  
D is for Digestive System  
E is for Endocrine System  
R is for Reproductive System  
S is for Skeletal System

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**Muscular System**

M stands for the MUSCULAR SYSTEM  
The body has three different kinds of muscles.  
  - The heart or cardiac muscle.  
  - Smooth muscles, which control the body’s involuntary operations.  
  - Striated muscles, which carry out our voluntary movements.

Examples: Smooth muscles control breathing, the operation of the pyloric valve (a muscle located at the base of the stomach), dilation and constriction of pupils, and all other things that we do not consciously control.  

All three types of muscles are examined at various stages of the drug influence evaluation.

**Urinary System**

U is for the URINARY SYSTEM.  
The system consists of two kidneys, the bladder, ureters connecting the kidneys to the bladder, and the urethra, which transports the urine out of the body.

Kidneys filter waste or harmful products, such as drugs and their metabolites, from the blood, and dump these waste products into the bladder.
The Ten Systems of Human Physiology: MURDERS, INC. (Cont.)

M is for Muscular System
U is for Urinary System
R is for Respiratory System
D is for Digestive System
E is for Endocrine System
R is for Reproductive System
S is for Skeletal System

Respiratory System

The first R in “MURDERS INC” stands for the RESPIRATORY SYSTEM.
The major parts of the Respiratory System are the lungs and the diaphragm.
The diaphragm is a smooth muscle that draws the air into the lungs and forces it out.
Lungs take in oxygen and transfer it to the blood, and remove carbon dioxide and some other waste products from the blood, and expel them into the outside air.

Digestive System

D stands for the DIGESTIVE SYSTEM.
Major components of this system are the tongue, teeth, esophagus, stomach, intestines, liver, and pancreas.
The Digestive System breaks down large particles of food, until they are of a size and chemical composition that can be absorbed in the blood.

Endocrine System

E is for the ENDOCRINE SYSTEM.
The Endocrine System is made up of a number of different glands that secrete hormones.

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Hormones are complex chemicals that travel through the blood stream and that control or regulate certain body processes.

Some drugs can mimic the effects of certain hormones, or can react with the hormones in ways that alter the hormones' effects.

**Reproductive System**

The second R in "MURDERS INC" stands for the REPRODUCTIVE SYSTEM.

The functions of the reproductive system fall into two categories:

- self-producing (cytogenic), and
- hormone producing (endocrinic).

We are primarily concerned with hormone production since the hormones produced by the reproductive system aid the nervous system in its regulatory role.

**Skeletal System**

S is for the SKELETAL SYSTEM.

Consists of bones, cartilage and ligaments.

The Skeletal System provides support to the body, permits movement, and forms blood cells.
The Ten Systems of Human Physiology: MURDERS, INC. (Cont.)

I is for Integumentary System
N is for Nervous System*
C is for Circulatory System*

* For DRE officers, these are key systems

Integumentary System
The I in “INC” stands for the INTEGUMENTARY SYSTEM.
Consists of the skin, hair, fingernails and toe nails, and accessory structures.
The chief functions of the Integumentary System include protection of the body, control of the body temperature, excretion of wastes (i.e. through sweat) and sensory perception.

Nervous System
N is for the NERVOUS SYSTEM.
This system consists of the brain, the brain stem, the spinal cord and the nerves.
Nerves keep the brain informed of changes in the body’s external and internal environments.
Nerves also carry messages from the brain to the body’s muscles, tissues and organs.
The nervous system controls, coordinates and integrates all physiological processes, so that normal body functions can be maintained.
Circulatory System

C is for the CIRCULATORY SYSTEM.

For our purposes, the most important parts of the Circulatory System are the heart, the blood vessels (e.g., arteries, veins, capillaries, etc.) and the blood.

Blood is the body’s primary transport mechanism: it carries food, water, oxygen, hormones, antibodies, etc. to the body’s tissues and organs.

Blood is also primarily responsible for carrying heat throughout the body.

Blood is the main transport mechanism for bringing drugs to the brain.

The heart, of course, pumps the blood and causes it to circulate throughout the body.
C. The Concept of Homeostasis

Homeostasis is the dynamic balance, or steady state, involving levels of salts, water, sugars and other materials in the body’s fluids.

Human body is exposed to a constantly changing external environment.

Changes are neutralized by the internal environment – the blood.

Oxygen, foods, water and other substances are constantly leaving bodily fluids to enter cells, while carbon dioxide and other wastes are leaving the cells to enter these fluids.

Yet, the chemical composition of these fluids remains within very narrow limits.

This phenomenon is called homeostasis.

Drugs interfere with the homeostatic mechanisms and produce signs and symptoms that can be recognized by a trained DRE.

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D. A Simple View of the Heart and Circulatory System

Heart and Circulatory System

Circulation is a closed system, where blood is propelled by contractions of the heart.

Blood is driven into arteries, arteries divide into smaller and smaller branches and finally into meshwork of fine capillaries which pervade body tissues.

Meshwork joins up again to form small veins which become larger trunks as they travel centrally towards the heart.

There are two separate circulation systems:

Systemic system involves the whole body and is driven by the left side of the heart.

Pulmonary system deals with the passage of blood through the lungs and is driven by the right side of the heart.
The heart is the pump and has two sides:
Consists of the left atrium and ventricle. The upper chamber (atrium) receives blood from the great veins, the lower chamber discharges blood into the great arteries.
Left side pumps blood through the aorta and the arteries to the tissues.
Blood, after passing through the tissues, returns via the veins to the right side.
Right side pumps blood through the pulmonary artery to the lungs and returns it to the left side of the heart again via the four pulmonary veins.
Consists of the right atrium and ventricle.

**NOTE:** The pulmonary artery is the only artery that carries de-oxygenated blood; all other arteries carry blood that has received fresh oxygen from the lungs. Likewise, the pulmonary vein is the only vein that carries blood rich in oxygen; all other veins carry blood depleted of oxygen back to the heart.

The normal heart continues to beat regularly and continuously, with a rest interval never longer than a fraction of a second.
Heart rate is the number of beats per minute.
Pulse rate is the number of pulsations per minute.
**For DRE purposes, the average range for the pulse rate is 60-90 pulsation beats per minute.**
Blood pressure (BP) is the force of the blood circulating in the arteries. BP is categorized as systolic or diastolic BP. Systolic pressure is the maximum force that occurs during contraction. Diastolic pressure represents the minimum force that occurs when the heart relaxes.

The DRE average range for systolic blood pressure is 120 to 140. The DRE average range for diastolic blood pressure is 70 to 90.

**Control Systems**

The functions of the organs of the body are controlled in two ways:

- This is a function of the endocrine system.
- One, by sending “chemical messengers” known as hormones via the blood stream from an endocrine gland where they are produced.
- Second, system of control is by means of the nervous system.
E. The Nervous System

Clarification: Nerves are often pictured as telephone or telegraph wires.

The nerves that carry messages to and from the brain often are pictured as “wires” that carry electrical signals.

A more accurate, but still simplified concept would envision a nerve as a series of broken wire segments, with the segments separated by short spaces, or gaps.

We can imagine messages running along the “wire segments” in much the same manner that electrical impulses run along telephone wires.

When the message reaches the end of the “wire segment,” it triggers the release of chemicals that flow across the gap, and contact the next “wire segment.”

When the chemical contacts the next wire segment, it generates an electrical impulse which runs along the wire until it reaches the next gap.

At that gap, the message again triggers the release of chemicals that flow across to the next “wire segment,” and the process continues.
How a Neurotransmitter Works
Steps are numbered sequentially:
1. Neuron makes a neurotransmitter
2. Synaptic vesicles are small membrane bound structures in the axon terminals of nerve cells that contain neurotransmitters. The vesicles release neurotransmitters into the synaptic gap
3. Neurotransmitter enters gap to transmit electrical impulse to receptor site
4. Receptor performs a function

In our simple model of nerves, each “wire segment” corresponds to a nerve cell, called a neuron.

The chemical that flows across the gaps separating neurons is called a neurotransmitter.

The body has a number of different neurotransmitters; each carries a different chemical message.

The sequence of how a neurotransmitter works:
1. The neuron makes a neurotransmitter.
2. Synaptic vesicles are small membrane bound structures in the axon terminals of nerve cells that contain neurotransmitters. These vesicles release neurotransmitters into the synaptic gap.
3. The neurotransmitter enters the synaptic gap to transmit electrical impulse to the receptor site.
4. The receptor performs a function

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Each neuron, or “wire segment” has three main parts:

- the cell body
- the axon
- the dendrite

The axon is the part of the neuron that sends out the neurotransmitter, or chemical messenger.

The dendrite is the part that receives the neurotransmitter.

The gap between two neurons is called a synapse, or synaptic gap.
Classification of Nerves

Some nerves carry messages away from the brain, to the body’s muscles and organs. These are called motor, or efferent nerves.

The brain uses motor nerves to send commands to the heart to beat, the lungs to breathe, the muscles to contract or expand, and so forth.

Other nerves carry messages to the brain, i.e. from the eyes, ears and other senses, from the muscles, etc.

These are called Sensory, or Afferent nerves.

The brain decodes the messages that come along the sensory nerves to monitor the condition of the body and of the outside world.

A fundamental notion: if something interferes with the messages the brain sends along the motor nerves, the brain’s control over the heart, the lungs, the muscles and other organs will be distorted.

Another fundamental notion: if something interferes with the messages the brain receives from the sensory nerves, the brain’s perception of the outside world and of the body’s status will be distorted.
There are two sub-systems of motor nerves:

- The voluntary nerves send messages to the striated muscles that we consciously control.
- The autonomic nerves send messages to the muscles and organs that we do not consciously control, i.e. smooth muscle and cardiac muscle.
- The Autonomic sub-system is divided into two groups.
- The Sympathetic nerves command the body to react in response to fear, stress, excitement, etc.

**CLARIFICATION: Sympathetic nerves control the body’s “fight or flight” responses.**

**EXAMPLES:** Sympathetic nerves carry the messages that cause: blood pressure to elevate, pupils to dilate, sweat glands to activate, hair to stand on end, heartbeat to increase and strengthen, blood vessels of the skin to constrict, the walls of the hollow viscera to relax (inhibiting digestion).

- Parasympathetic nerves carry messages that produce relaxed and tranquil activities.
Autonomic Sub-Systems

- Sympathetic nerves
- Parasympathetic nerves

**EXAMPLES:** Parasympathetic nerves carry messages that cause: pupils to constrict, heartbeat to slow, peripheral blood vessels to dilate, blood pressure to decrease.

Certain neurotransmitters (i.e. chemical messengers) aid in the transmission of messages along sympathetic and parasympathetic nerves.

Some drugs mimic the action of these neurotransmitters: when taken into the body, these drugs artificially cause the transmission of messages along sympathetic or parasympathetic nerves.

Drugs that mimic the neurotransmitter associated with sympathetic nerves are called sympathomimetic drugs.

Sympathomimetic drugs artificially cause the transmission of messages that produce elevated blood pressure, dilated pupils, etc.

Examples: CNS Stimulants, Hallucinogens, and to some extent Dissociative Anesthetics and Cannabis.

Drugs that mimic neurotransmitters associated with parasympathetic nerves are called parasympathomimetic drugs.

Parasympathomimetic drugs artificially cause the transmission of messages that produce lowered blood pressure, drowsiness, etc.

Examples: Narcotic Analgesics and CNS Depressants.
Neurotransmitters

Although there are more than 100 chemicals in the brain, only about two dozen probably are true neurotransmitters.

Among the primary neurotransmitters that have been identified are:

- Norepinephrine (also called Noradrenaline)
- Acetylcholine
  
  Acetylcholine plays a role in muscle control, and affects neuromuscular or myoneural junctions.
- Dopamine
  
  Dopamine plays a role in mood control and is used in treating Parkinson's Disease.
- Serotonin
  
  Serotonin is a vasoconstrictor, thought to be involved in sleep, wakefulness, and sensory perception. Tryptophan is a precursor to serotonin, and has been used to treat insomnia.
- Gamma Amino Butyric Acid (Abbreviated GABA)
  
  GABA inhibits various neurotransmitters and also causes a release of growth hormones.
Endorphins and Enkephalins

- The body's natural pain relievers
- Many drugs artificially induce the effects of neurotransmitters and hormones

These are the body’s natural pain relievers.
There are many drugs that artificially induce the effects of neurotransmitter and hormones.
F. How Drugs Work

In very simple terms, drugs work by artificially creating natural body reactions generally associated with the work of neurotransmitters and hormones.

Therapeutic doses of legitimate prescription and over-the-counter drugs are designed to produce mild and carefully controlled simulations of the natural action of neurotransmitters and hormones.

Large, abusive doses of drugs may produce greatly exaggerated simulations of the natural action of hormones and neurotransmitters, sometimes with disastrous results.

Example: Cocaine (a sympathomimetic drug) may artificially create a message commanding the heart to beat so rapidly that cardiac arrest results.

When a person ingests a drug and artificially simulates the natural action of hormones and neurotransmitters, the body's dynamic balance is disrupted.

The body automatically responds to the presence of the drug by producing other hormones and chemicals that can oppose the drug's effects, and bring the body back into balance.

Example Number One

If a person ingests a stimulant drug that mimics neurotransmitters associated with the sympathetic nerves, the body may react by excreting hormones that depress the bodily functions that the drug is exciting.
If a person ingested Cocaine, for example, the Cocaine would artificially stimulate the body functions. The body would then produce hormones and neurotransmitters to slow down the body functions to try to maintain homeostasis.

Example Number Two

If a person ingests a drug that depresses some bodily function, the body may pour out one of its natural chemicals that stimulate that same function.

An interesting situation can occur when the drug is no longer psychoactive.

The chemicals produced by the body in an effort to counteract the drug may still be active.

These natural chemicals have exactly the opposite effect on the body that the drug had: after all, that is precisely why the body produced those chemicals.

As a result, the person may feel, appear and act in a manner exactly opposite to the way he or she would feel, appear and act when under the influence of the drug.
“Downside Effect”

When the body reacts to the presence of a drug by releasing hormones or neurotransmitters to counteract the effects of the drug consumed

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Downside

It is not uncommon for a DRE to encounter someone on the “downside.”

We call this situation being on the “downside” of the drug.

Example: with cocaine (a drug that is metabolized, or broken down by the body fairly quickly) the user may be exhibiting drowsiness and general depression by the time the DRE is called to the scene.

The concept of “downside” will be especially important to us when we discuss the effects of CNS Stimulants and drug combinations.

Then the body attempts to “counteract” the stimulant effects. When the effects of the drug diminish, the results may mimic a CNS Depressant or a Narcotic Analgesic.
“Negative Feedback”

When the brain accommodates the routine presence of a drug by turning off the supply of natural chemicals that correspond to the drug.

Negative Feedback

Another interesting effect that drugs can produce is called Negative Feedback. By taking the drug, the person artificially simulates the action of certain hormones and/or neurotransmitters.

If the person continues to take the drug, the body may simply cease producing the natural chemicals that the drug simulates.

In effect, the body comes to rely on the drug to supply itself with those chemicals.

Example of Negative Feedback: when people regularly use heroin, cocaine, or marijuana, their bodies may cease producing the neurotransmitters and hormones known to be crucial for proper pain relief, stress reduction, mental stability and motivation.

One result of this may be increased tolerance to the drug: since the body isn’t producing its own natural chemicals, it can more easily stand the drug.
Tolerance

- May exhibit relatively little evidence of impairment on the psychophysical tests
- Even tolerant drug users, when impaired, usually exhibit clinical evidence (i.e. vital signs, eye signs, etc.)

Even tolerant drug users, when impaired, usually exhibit clinical evidence (i.e., in the vital signs and eye signs – such as HGN).

Physical Dependence

Another result may be physical dependence, or addiction.

In simplest terms, people take drugs because they like the feelings the drugs produce.

The artificial simulation of the natural action of hormones and neurotransmitters appears to permit the user to create any feeling or mood he or she desires.

As time goes on, and negative feedback develops, the user finds that he or she can only achieve those feelings and moods if the drug is taken.
**Metabolite**

A chemical product formed by the reaction of a drug with oxygen and/or other substances in the body.

One final concept is important for an understanding of how drugs work. A Metabolite is a product of metabolism which is the chemical changes that take place when the drug reacts with enzymes and other substances in the body. The body uses chemical reactions to break down the drug, and ultimately to eliminate it.

Example: when we drink alcohol, we initiate a series of chemical reactions that ultimately transform the alcohol into harmless carbon dioxide and water.

Sometimes, metabolites of the original drug are themselves drugs, and cause impairment.

For example, the body quickly metabolizes heroin into morphine, and it is the morphine that actually produces the effects the heroin user experiences.
G. Medical Conditions Which Sometimes Mimic Drug Impairment

Certain medical conditions or injuries may cause signs and symptoms similar to those of drug impairment.

- Bipolar Disorder (Manic Depression) – a condition characterized by the alteration of manic and depressive states.
- Conjunctivitis – inflammation of the conjunctiva.
  
  Conjunctivitis is a condition caused by infection, allergy, or irritation of the mucous membrane lining of the eyes, resulting in a “pink eye” appearance. A casual observer might mistake this for the bloodshot conditions associated with Cannabis or alcohol.
- Diabetes – a condition that can result in insulin shock (taking too much insulin) which may produce tremors, increased blood pressure, rapid respiration, lack of coordination, headache, confusion, and seizures.
  
  The most common problem with diabetics arises when they take too much insulin, so that their blood sugar levels become extremely low. They may be very confused, sweat profusely, and exhibit increased pulse rate and increased blood pressure.
- Head Trauma – normally due to a severe blow or bump to the head.
  
  Head trauma may injure the brain and create disorientation, confusion, lack of coordination, slowed responses and speech impairment.
• Multiple Sclerosis (MS) – a degenerative muscular disorder.  
MS is a progressive disease in which the nerve fibers of the brain and spinal cord lose their myelin cover. Some signs and symptoms are abnormal sensations in the face or extremities, weakness, double vision, etc.

• Shock – a sudden or violent disturbance in the mental or emotional faculties.  
A shock victim may be dazed, uncoordinated, non-responsive.
Other indicators include: extremely low blood pressure, fast but weak pulse, dizziness, moist clammy skin, profuse sweating, rapid shallow breathing, blue lips and fingernails.

• Stroke – a medical condition caused by a rupture or obstruction (as if by clot) of an artery of the brain.

Others – Carbon Monoxide poisoning, Seizures, Endocrine disorders, Neurological conditions, Psychiatric conditions and infections.

Normal conditions can affect vital signs: Exercise, Excitement, Fear, Anxiety, Depression, Other

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Medical Rule Out

- For purposes of DRE and the DEC Program, a medical rule out is defined as:
  
  “A determination made by a DRE that the condition of a suspected impaired driver is more likely related to a medical issue that has affected the subject’s ability to operate a vehicle safely.”

DRE Medical Rule Out Definition

There are times when a DRE may encounter situations where a subject arrested for drugged driving may be suffering from a medical condition that has affected the subject’s ability to operate a vehicle safely. Once the DRE makes this determination the evaluation is considered a “medical rule out.” In other words, the DRE through his or her evaluation has ruled out impairing substances and while doing so, identified signs and symptoms that are consistent with a medical issue. Once the DRE makes the determination, the DRE should consider taking appropriate steps to ensure the subject is referred to the proper medical personnel.

In such cases, the DRE should prepare the DRE drug evaluation report documenting his or her findings that support an opinion of a DRE medical rule out.

For purposes of DRE and the DEC Program, a medical rule out is defined as, “A determination made by a DRE that the condition of a suspected impaired driver is more likely related to a medical issue that has affected the subject’s ability to operate a vehicle safely.”

The suggested way to document this type of opinion in Step 11 of the DRE report would be: “It is my opinion that (Subject's name) is a medical rule out and is unable to operate a vehicle safely.”
H. **Summary**

Basic understanding of how the body works is necessary to:

- Understand why the drug evaluation is conducted in a systematic manner.
- Understand why the results, when viewed in their totality, provide reliable indicators of impairment within broad categories of drugs.
- This limited overview will not qualify participants as medical specialists.
- The knowledge gained during this session must be supplemented by additional reading and/or instruction.
- The body of knowledge in this area is being constantly expanded.
- The body maintains homeostasis (equilibrium) by constantly adjusting to changes in the external and internal environment:
- When drugs are introduced into the body this process comes into play.
- When drugs interact in the body they tend to:
  - speed things up, or slow things down, or confuse signals, or block signals, or some combination of the above.
The effects of drugs can be detected and/or observed in the drug evaluation.

**Drug Evaluations**

**Physiological Pursuit**

For review of the Physiology and Drugs session, questions can be asked of the participants as if it were a game of Trivial Pursuit. See attachment.

**QUESTIONS?**
TOPICS FOR STUDY

1. What is a neurotransmitter? What is a hormone?

2. What is a dendrite? What is an axon? What is a synapse?

3. Do arteries carry blood toward the heart or away from the heart?

4. What is unique about the Pulmonary Artery?

5. What are the two types of nerves that make up the Autonomic Nervous Sub-System?

6. Cocaine sympathomimetic or parasympathomimetic? What about Heroin?

7. Explain the concept of the “downside effect.” Explain the concept of “Negative Feedback.”

8. What do we call the nerves that carry messages away from the brain? What do we call the nerves that carry messages toward the brain?
QUESTIONS FOR PHYSIOLOGICAL PURSUIT

1. Name the major body systems.

2. What vein carries oxygenated blood?

3. What is the function of the endocrine system?

4. Explain the “downside” effect of a drug.

5. Define homeostasis.

6. Hair and nails are part of what system?

7. Name the two circulatory systems.

8. The functions of the organs of the body are controlled by what two systems?

9. Define synapse, axon, and dendrite.

10. Define neurotransmitter and hormone.
11. _______ nerves carry messages AWAY from the brain to the body’s muscles and organs.

12. The _______ nervous system commands the body to react to stress, fear, and excitement.

13. Explain “negative feedback.”

14. What two types of nerves make up the autonomic nervous subsystem?

15. Define metabolite.