EXA 401: General Concepts of Exposure Assessment
Instructor Notes

Course Description: The objectives of this course are to provide participants with a basic foundation in the concepts and principles of human exposure assessment. Participants will be introduced to the various components of an exposure assessment as well as relevant key terminology. Fundamentals that will be covered include: intake, uptake, and dose; applied, potential, internal, and biologically effective dose; acute dose, average daily dose, and average lifetime dose; and dermal, oral, and respiratory dose. This course will familiarize participants with EPA's existing and soon-to-be updated *Exposure Assessment Guidelines* and other key exposure assessment resources.

Expected Course Duration: Approximately 30-45 Minutes

Terminal Learning Objective: Understand the basic concepts and principles associated with human exposure assessment.

Enabling Learning Objectives:
- Understand the role of exposure assessment in the risk assessment process
- Understand basic concepts of exposure assessment, including:
  - Exposure, intake, uptake, and dose
  - Applied, potential, internal, and biologically effective dose
  - Acute, average, daily, and lifetime average dose
  - Temporal concepts, including exposure frequency, duration, and averaging time
  - Routes of exposure
  - Equations to estimate exposure and dose

Course Materials

- EXA 401 Reading Packet

Course Overview/List of Slides

TITLE SLIDE

What You Can Expect to Learn from this Course (Slide 1)

- This course introduces the basic concepts and principles of human exposure assessment.
- We will first discuss how exposure assessment fits into the larger context of risk assessment.
- Then, to illustrate the concepts and definitions related to exposure assessment, we will discuss four separate exposure scenarios and various terms and definitions related to exposure assessment. This process is intended to assist in learning and applying the terminology of exposure assessment.
- Next, we will introduce other important elements of exposure and the various factors that contribute to individual and population variability in exposure assessment.
- Finally, we will introduce the concept of uncertainty as it applies to exposure assessment, and conclude by highlighting some important EPA resources for exposure assessors.

INTRODUCTION AND BACKGROUND CONCEPTS (SLIDE 2)

- Let's start by discussing background concepts and defining some key terms.

The Risk Analysis Paradigm and the Role of Exposure Assessment (Slide 3)

- The risk analysis paradigm is made up of three main areas: research, health risk assessment, and risk management evaluation.
- Exposure assessment is an important part of the paradigm and plays a key role in risk assessment.
- When a problem or hazard is identified, the potential effects on human health are assessed, and the possible pathways of exposure are evaluated. Human health risk is quantified through the synthesis of hazard identification, dose-response assessment, and exposure assessment. You may recall from previous courses that human health risk can be defined as "the probability of adverse effects resulting from exposure to an environmental agent or mixture of agents" (U.S. EPA, 2003).

The Dose Makes the Poison (Slide 4)

- A critical point to understand is that without exposure, there is no risk. The fact that a chemical is hazardous – for example, dioxin is believed to be highly carcinogenic – does not mean that a release of dioxin from a source guarantees that the risk is high. There must also be exposure to the released dioxin to result in an elevated health risk.
- This can be represented by the simple equation, Hazard × Exposure = Risk
- A phrase that follows along these lines is "the dose makes the poison." This concept is first attributed to Paracelsus, a 16th century Swiss physician and chemist. He noted that

all things are poisons and the amount we are exposed to determines whether the substance is harmful or not. In the context of risk assessment, the amount of a toxic substance to which someone is exposed is a critical piece of the equation in estimating the harm that might occur.

- Using these principles, exposure assessment can be employed to inform decision-making for future risks and to evaluate past exposures. When estimating future risks there is some uncertainty, but the benefit is that risk mitigation can help prevent health impacts to a population. When assessing past exposures, it is possible that health effects have already occurred, but the risk assessment process allows us to more accurately quantify the health risk to a population based on known parameters.
- Sources: NRC (2009, 1983); U.S. EPA (1992b); IPCS (2004)

The Utility of Risk Assessment in Environmental Decision-Making (Slide 5)

- A primary purpose of exposure assessment is to provide a reliable estimate of dose for use in risk assessment. The dose is then used to assess the relative hazard of the contaminant and characterize the overall risk.
- Exposure assessment is a key step in risk assessment and risk characterization. Conclusions based on exposure assessment, and the risk characterization that depends directly on the exposure assessment results, ultimately inform risk management decisions, which can have substantial impacts on public health.
- Risk management decisions can have multiple impacts – from bans or restrictions on chemicals or practices, to updated standards for pollutants, as well as changes in research priorities or regulations.

Source-to-Effect Continuum (Slide 6)

- The figure in this slide depicts a conceptual framework of exposure assessment, beginning at the source, and moving through exposure to an effect or outcome.
- Let’s look at the process of exposure assessment on this continuum in more detail.
- One way to look at exposure is to consider it as the nexus between environmental contamination (that is, the release of a toxic substance to the environment) and health effects that occur as a result of this contamination.
- Starting on the top left of the figure, a chemical originates from a source. Once in the environment, chemicals are subject to environmental fate and transport processes. These processes impact the amount and form of the chemical in the environment. Some of the chemical may break down, or a portion may become immobile or inactive.
- The changes that occur between the source and the site of exposure affect the resulting environmental concentration. Exposure is therefore a function of the environmental concentration of the stressor, fate and transport processes, and time.
- When the exposure occurs, the chemical moves into the body of the exposed individual. The amount that makes it into the body and to a specific target in the body is the target tissue dose, and is dictated by interactions of the chemical with the metabolic processes

of the body. When the chemical interacts with the biological target inside the body, a biological event may occur. Depending on the type and extent of the event created, an effect or outcome can occur. This effect may be minor, in the case of skin irritation from exposure to diluted chlorine bleach; or it may be major, in the case of nervous system dysfunction and shutdown due to overexposure to an organophosphate pesticide.

- The exposure portion of this course will focus on the left side of this figure, ending at the exposure box shown on the bottom of this figure. Except for a discussion on absorption, the modules on health hazard further address the disposition and effects of contaminants in the body once exposure has occurred.
- Sources: U.S. EPA (1992b); Williams et al. (2010)

What is Exposure? (Slide 7)

- Exposure is defined as contact made between a chemical, physical, or biological agent and the outer boundary of an organism.
- Exposure can be thought of as a two-step process in which contaminants enter the body through contact and absorption.
  - Contact occurs when a substance or mixture of substances is absorbed through the skin or enters the body by the nose, mouth or other opening. Typically, risk assessors consider exposure to occur through one of three exposure routes: inhalation, ingestion, or dermal contact.
  - Absorption is a process that occurs when a substance is taken into the body from the respiratory system, gastrointestinal tract, or through the skin.
- Exposure is quantified, or measured, as the amount of an agent available at the exchange boundaries of the organism (for example, the skin, lungs, or gut).
- Source: U.S. EPA (1992b)

The Exposure Equation (Slide 8)

- Exposure over a period of time can be represented by the conceptual equation on this slide, in which the magnitude of exposure is a function of concentration of the stressor, time, and behavior.
  - In this context, time refers to the duration that the exposure occurs. The exposure can be acute, meaning it occurs in a short time period, usually less than a day. The exposure could also be chronic, meaning it occurs either continuously or consistently over a longer time period, up to a lifetime exposure.
  - Behavior refers to the contact rate, by inhalation, ingestion, or dermal contact.
- An important concept that's inherent to this equation is that there is a temporal component to the quantification of exposure. In other words, exposure cannot be fully characterized by an instantaneous concentration of a substance in a medium; rather, one must also evaluate how long that concentration persists and how it changes over time, in addition to how people come into contact with the chemical.
- Source: U.S. EPA (1992b)

What is Dose? (Slide 9)

- When a substance is taken into the body by one of the several routes of exposure discussed previously, the amount that gets into the body in a biologically available form is called the dose.
    - Dose is defined as: “The amount of a substance available for interactions with metabolic processes or biologically significant receptors after crossing the outer boundary of an organism” (U.S. EPA, 2003).
- There are a few different ways to think about dose:
    - Potential dose is the amount ingested, inhaled, or applied to skin, not all of which will be absorbed.
    - Applied dose is the amount at an absorption barrier (like the skin, respiratory tract, or gut) that can be absorbed by the body.
    - Internal dose is the amount absorbed and available for interaction with biological receptors.

DoseEquation (Slide 10)

- The dose equation is a way to calculate dose from known or estimated data on exposure. The potential dose, absorbed dose, and internal dose can be calculated using the dose equation, which is presented on this slide.
- The potential dose of a contaminant is the product of the contaminant concentration, intake rate, contact fraction, exposure duration and frequency divided by the averaging time and body weight.
- The absorbed dose is the potential dose multiplied by the fraction of the potential dose that is absorbed by the body. The absorbed dose is also equivalent to the internal dose.
- Dose is generally expressed in units of mass of the contaminant per mass of body weight for an individual over a set period of time. Units commonly used are milligrams of a chemical per kilogram of body weight per day. We will talk in more detail about the dose equation throughout this course.

Dose Illustrated (Slide 11)

- This slide is based on figures included in EPA’s 1992 Exposure Guidelines. They illustrate the potential, applied, internal, and biologically effective doses. The specific meaning of these terms varies by the exposure route: oral, respiratory, or dermal.
- In terms of exposure by the oral or respiratory route, the potential dose is the amount of chemical that gets in the mouth or nose, and the applied dose is what makes it to either the gastrointestinal tract or the lungs.
    - The applied dose is usually smaller than the potential dose.
- Dermal exposure routes are different than oral or respiratory exposure routes because of the absorption properties of the skin. The potential dose, when we are talking about dermal exposure, is the chemical and the matrix it is in (soil, for example) that could come in contact with the skin. It is unlikely that all of the potential dose will come into

contact with the skin. The amount of chemical contained in soil that does come into contact with the skin is the applied dose, because it is applied directly to the skin.

- In all cases, the internal dose is what gets past the barrier–either the skin, the lungs, or the stomach–and into circulation in the blood. The internal dose is the amount of the chemical that can interact with organs and tissues to cause biological effects.
- Source: U.S. EPA (1992b)

EXPOSURE ASSESSMENT: EXAMPLES OF EXPOSURE (SLIDE 12)

- We'll use four hypothetical exposure situations to introduce some important concepts in exposure assessment. This will also help us better define some important terminology.

Four Exposure Examples (Slide 13)

- Meet Jim. Over the next several slides, we're going to follow Jim through a series of scenarios. Jim has an older home. Jim is retired and spends most of his time at home either in the house cooking or out in his garden.
- There are a number of ways that Jim could be exposed to chemicals in and around his home. We will look at four specific exposure scenarios that could occur via different exposure routes to illustrate the concepts relevant to exposure assessment.
- The four situations we will review include four hazards around Jim's home:
  - benzene in Jim's drinking water,
  - nickel and lead in Jim's garden soil,
  - smoke in Jim's kitchen, and
  - pesticide residues on Jim's garden vegetables.
- We will look at how Jim might be exposed to these hazards as a result of drinking water, absorbtion through skin, inhalation, or eating, and review the concepts of exposure assessment through those examples.

? Can anyone identify other potential hazards or routes of exposure that Jim might encounter in and around his home, which we did not mention here?

Exposure Example 1: Benzene in Drinking Water (Slide 14)

- Jim gets his water from a well on his property. Jim drinks about two liters (approximately 1/2 a gallon) of water per day, and has done so for about 20 years. Jim's house is on a lot that's next to an old gas station, and there are underground storage tanks on that property. The tanks are old, and have started to degrade and leak.
- Each time Jim drinks a glass of water from his well, he is exposed to the water and all of the potentially harmful contaminants in the water. As we've discussed, an exposure occurs when a chemical or agent contacts the visible exterior of the person, making contact with the skin or openings into the body such as the mouth or the nose.
- Jim had his water tested recently, and the tests showed levels of benzene above the maximum contaminant level (MCL) of 5 parts per billion. When Jim drinks the water, the process can be referred to as intake of a substance (specifically the benzene in the

water) because the substance enters Jim's body without passing through a barrier. Intake in this situation only applies to ingestion exposures. We'll talk more about a related term, uptake, in the second scenario.

- Sources: U.S. EPA (2001, 1992b); U.S. EPA, Basic information about Benzene in drinking water.

Exposure Example 1: Benzene in Drinking Water (Slide 15)

- Since Jim drinks 2 liters of water every day, as he has been doing for the last 20 years, he gets a small dose of benzene every day. In terms of exposure assessment, this would be considered a chronic exposure.
    - Chronic exposures are repeated exposures by either ingestion, inhalation, or skin exposure for more than about 10 percent of a person's lifespan (U.S. EPA, 2003).
- The storage tank near Jim's house hasn't always been leaking. In fact, when Jim found out about the tank after he got his water tested, the inspectors estimated the tank had been leaking for about seven years, and the leak was slow. If we wanted to determine how much benzene Jim had been exposed to each day, on average, we could determine the average daily dose that was in Jim's water.
- In this situation, it may be a little difficult to determine how much benzene Jim was exposed to because we don't know exactly how long the tank has been leaking, or how much benzene was in the water throughout the last seven years. However, we can use some assumptions about benzene fate and transport, as well as Jim's exposure to estimate the average daily dose.

Exposure Example 1: Average Daily Dose (Slide 16)

- The average daily dose, ADD, can be calculated by multiplying the exposure concentration, C (the levels of benzene in the water that Jim drinks), by the intake rate, IR (how much water Jim drinks), the exposure duration, ED (how long Jim has been drinking the water), and the exposure frequency, EF, then dividing that product by the product of Jim's body weight, BW, and the averaging time, AT (the number of years over which the consumption is averaged).

Exposure Example 1: Lifetime Average Daily Dose (Slide 17)

- If nothing was done about the leaking tank, Jim could be exposed to benzene in his water for a long time. In some cases where we want to estimate what the exposure to an individual or population would be over a lifetime, we calculate the lifetime average daily dose, or LADD.
- The LADD can be calculated by multiplying the exposure concentration, C (the levels of benzene in the water that Jim drinks), by the intake rate, IR (how much water Jim drinks per day), the exposure duration, ED (how many days Jim has been drinking the water), and the exposure frequency, EF, then dividing that product by the product of Jim's body weight,BW, and the lifetime (usually 70 years is assumed).

  - Note that in this case, the averaging time, AT in the equation shown in the previous slide, is set equal to a lifetime.
- The average exposure over an entire lifetime is commonly calculated when evaluating cancer risk, because the human health reference values often used to quantify cancer risk (that is, an oral cancer slope factor or an inhalation or drinking water ingestion unit risk estimate) are estimated with respect to a full lifetime of exposure. For non-cancer risk, in contrast, we calculate only the average exposure during the duration that exposure occurred.
- Note that calculation of the LADD in this case (as in most cases) assumes future exposures.
- These are simplified dose equations that we are using to illustrate these concepts. In reality, we know that concentration, intake, and body weight will change over time, so we usually use computer programs or spreadsheets to calculate these dose estimates. We also don't necessarily calculate exposure for just a single person. It's often done for a population which introduces a lot of variability to these parameters. We'll talk more about this throughout the EXA courses.

Exposure Example 2: Skin Exposure to Soil Metals (Slide 18)

- Let's discuss a second situation with a different type of exposure.
- Jim loves to garden in his backyard, where he's been planting tomatoes and other vegetables for at least 20 years. He has four raised beds where he grows vegetables, and he likes to go out and get his hands dirty in the garden. Jim gardens about 9 months out of the year, and rarely uses gardening gloves.
- Jim buys soil for his raised beds from a local mulch business, and found out recently that some of the "Garden Magic" soil that he uses had elevated levels of nickel and lead. When Jim is done gardening, he usually washes his hands and forearms, which are covered in dirt.

Exposure Example 2: Skin Exposure to Soil Metals (Slide 19)

- When Jim's skin contacts the soil, he has an exposure to the soil and the contaminants in it. While the soil is on Jim's skin, some of the contaminants in the soil may move across his skin, and then into his body. The amount of lead and nickel that moves into Jim's body is called the internal dose. Since the internal dose crosses the absorption barrier of the skin, it is also referred to as the absorbed dose. The process by which the contaminants are taken into the body across an absorption barrier is called uptake.
  - Compare this to the intake of Jim's drinking water, in which the contaminant does not cross an absorption barrier before entering the body.
- Not all of the nickel and lead in the soil will make it across the skin and into Jim's body. In fact, lead is poorly absorbed across the skin (HSDB, 2010). Nickel can be taken into the body through the skin (ATSDR, 2005), but it is slowly absorbed. The amount of nickel and lead in the soil that ends up on Jim's hands and arms is called the potential dose. More specifically, the amount of nickel and lead that is in the soil which comes

into contact with Jim's skin is the applied dose. Not all of the nickel and very little of the lead in the applied dose will be absorbed into Jim's body.

- The amount of lead and nickel that does make it into Jim's body after passing across Jim's skin (the absorption barrier) is called the internal dose. Here, the internal dose is equal to the absorbed dose.

Exposure Example 3: Kitchen Smoke Inhalation (Slide 20)

- One of Jim's favorite things to do in the summer months is to have a home-made hamburger – topped with fresh veggies from the garden, of course. It gets really hot on some summer days, so instead of grilling outside, Jim sometimes cooks the burgers inside.
- On one occasion, Jim was cooking burgers in his kitchen and went to answer the door. His neighbor had stopped by and they got to talking. They had been talking for a while when Jim noticed the smell of smoke. He ran to the kitchen and realized the burgers were burning and there was smoke everywhere. Jim breathed in quite a bit of smoke while attempting to clear the air.

Exposure Example 3: Kitchen Smoke Inhalation (Slide 21)

- The smoke that Jim breathed in made him hoarse and a little sick for a couple of days, with a nasty cough that eventually cleared up. Jim's exposure to the smoke only lasted a few minutes, but it was serious enough to affect his health, at least temporarily. A short term exposure like this is referred to as an **acute exposure**, and lasts no longer than a day.
- There are a wide range of contaminants in smoke, including particulates, volatile compounds, and a complex mixture of combustion by-products. This is a different situation than the first two examples, where we were relatively sure what contaminants Jim was exposed to. It is likely that Jim was exposed to all of these compounds when he breathed in the smoke.

Exposure Example 4: Ingestion of Pesticide Residues (Slide 22)

- Jim loves to cook and eat, and each spring he really looks forward to growing tomatoes and peppers in his garden. Jim doesn't usually use any pesticides, but every once in a while, he gets a really bad infestation of potato beetles and uses some malathion to control the problem. Sometimes Jim gets exposed to a little bit of the spray from the malathion while he's treating the plants.
- Jim really loves fresh tomatoes right off the vine. He usually washes the produce once it's in the house, but has a habit of grazing on tomatoes and peppers while he's out in the garden. Sometimes he may eat almost a pound of tomatoes while he's out there – they're just so good! Besides Jim's grazing, or incidental consumption, of produce in the garden, Jim also eats some store-bought vegetables that may have pesticide residues on them.

- Risk assessors may take into account residues on unwashed produce grown at home and purchased in the market, in their risk assessments.

Exposure Example 4: Ingestion of Pesticide Residues (Slide 23)

- The residue of malathion on Jim's tomatoes and peppers comes into contact with Jim when he eats the food. Once the peppers and tomatoes are in Jim's stomach, the malathion residue is absorbed by Jim's stomach. The amount of malathion in Jim's stomach is the applied dose in this case, and the amount that makes it across his stomach lining and into his blood is the internal dose. The applied dose is the amount of a substance that comes into contact with the absorption boundaries of the body.
- Malathion is a chemical that can affect the nervous system by interfering with the enzyme acetylcholinesterase. When malathion gets into the nervous system from the blood, it can bind to acetylcholinesterase and prevent the nerves from firing properly. The proportion of the malathion that makes it from the peppers and tomatoes, through Jim's stomach, and into the nervous system is the biologically effective dose.
    - The biologically effective dose is defined as the amount of a substance that reaches the cells, sites, or membranes where adverse effects occur. This amount is usually much smaller than the applied dose because it has been filtered by the body, sometimes by multiple tissues.

Exposure Examples: Concepts Introduced (Slide 24)

- In the four examples involving Jim's various exposures, we covered a number of terms and concepts. The terms are summarized here for each situation.
- Each situation involved different routes of exposure, exposure durations, sources of contaminants, and degrees of uncertainty. However, all four situations involved a contaminant of concern, an exposure pathway, and factors affecting the type and extent of exposure.
- Next, we will discuss exposure assessment in more detail, focusing on the elements of exposure and exposure factors.

EXPOSURE CONSIDERATIONS (SLIDE 25)

Individual- versus Population-Level Assessments(Slide 26)

- Our examples thus far have dealt with one person, but exposure assessment is frequently conducted for populations or groups of people. Public health professionals that conduct population-level health risk assessments need to have data on a number of different factors for the population they are concerned with in order to assess exposure more accurately.

- Characteristics of the population of interest include food and water intake rates, non-dietary ingestions, inhalation rates, behavior patterns, and other factors relevant to the scenario.
    - For example, immunodeficiency status could be important if the chemical of concern poses a hazard to the immune system. If the chemical of concern is a developmental hazard, then the number of women of child-bearing age would also be an important population-level exposure factor.
- In addition, variability and uncertainty in the exposure factors must be considered for each estimate. We will talk about these in a little more detail now and also in the other EXA courses.

Elements of Exposure (Slide 27)

- Now that we've talked about some examples, let's look more closely at the elements of exposure: pollutant source, exposure pathways, contaminants, and receptors. These elements allow us to characterize the exposure of interest and discover how it might affect human health.
- The pollutant source is a key element to assessing exposure. In order to understand how individuals are being exposed, we must first find out where the pollutant is coming from. In scenario 1, the pollutant source was the storage tank, which was contaminating Jim's water supply.
- Once the pollutant source has been identified, the specific exposure pathway of concern can be determined. The pathway is the connection between the pollutant source and exposure, and is useful in identifying exposures of concern. In scenario 2, the pathway of concern was skin exposure from contaminated soil after Jim worked in the garden with his bare hands.
- When the exposure pathway is identified, it may be possible to determine which contaminants are of concern. In scenario 1, we were concerned with the contaminant benzene in the water, which we knew was a problem based on water testing.
- The term receptor can refer to the individual or the population that is exposed. We need to know details about the receptor population in order to correctly apply exposure factors for that group. In these examples, the receptor is Jim.

Exposure Factors (Slide 28)

- Our example scenarios with Jim were helpful to understand exposure and some related concepts in exposure assessment. However, our discussion was limited only to Jim.
- One set of factors describing variability within a population are commonly referred to as exposure factors (U.S. EPA, 1997), and include things like food and water ingestion rates, body weights, activity factors, use of consumer products, and residential characteristics.
- The other key factor for describing population variability is the range of concentrations of the contaminant in the exposure media being examined.

Uncertainty and Variability (Slide 29)

- Uncertainty and variability are important considerations for an exposure assessment. We will talk about both of these in more detail in the next courses, so for now, we will just introduce the definitions.
- Uncertainty stems from a lack of knowledge either from incomplete data or an incomplete understanding of a process. Uncertainty can often be reduced by collecting more data or better data (U.S. EPA, 2010).
- In exposure assessment, just as in other components of the risk assessment process, we compensate for uncertainty by using approximations and making assumptions.
- Variability refers to heterogeneity or diversity within a data set; it's a property that is inherent to a data set and it cannot be reduced or eliminated. We can characterize variability using more data or try to further describe it (U.S. EPA, 2010).
- For example, the concentration of a pollutant in a river may be uncertain, variable, or both.
    - If the concentration has not been measured, or if there is uncertainty in the measurement methods, then the concentration is uncertain. The uncertainty can be reduced by collecting more or better data.
    - The concentration of the pollutant in the river is also variable. The measured concentration of pollutant in the water could vary depending on the amount of rainfall feeding into the river and the speed of the current at the time it is measured. While we cannot reduce this variability, we can characterize and describe it by collecting data on the amount and timing of rainfall related to our measurements of concentration.

Variability versus Uncertainty in Water Intake(Slide 30)

- It is useful to compare uncertainty to variability for a given exposure factor to illustrate the differences between the two concepts (U.S. EPA, 1992b). For this example, we'll use the exposure factor of water intake.
- One major difference between variability and uncertainty is that variability in the population is known, but uncertainty is unknown. We are aware that variability exists and though we cannot reduce or eliminate it, we can characterize it. Uncertainty, on the other hand, exists because we do not or cannot know all of the information needed to completely characterize the situation.
- The distribution, or range of water intake can vary within age groups or population groups. These differences in intake can be due to participation in specific activities or due to climate pressures. Exposure factors can be used to account for this variability, but true variability of a population is difficult to capture. Variability can also include contaminant-related factors, such as contaminant concentrations in water. The contaminant concentrations can vary geographically or temporally.
- Uncertainty in this situation exists in several areas, including water intake data for the population, concentration of the stressor in the media, or other exposure information for the population of concern. There may also be uncertainty about the geographic extent of

the population exposed, which could be due to limited monitoring data or uncertainty about the fate and transport of the stressor in question.

EPA's Guidelines for Exposure Assessment (Slide 31)

- EPA's Guidelines for Exposure Assessment were last revised in 1992, but an updated version is in the works and is expected to be released soon.
- The 1992 (U.S. EPA) guidelines introduce general concepts in exposure assessment and provide guidance on planning exposure assessment.
- Chapters 3 and 4 describe gathering and developing data and then provide details on using data to estimate exposure and dose.
- Chapter 5 discusses the assessment of uncertainty and variability in an exposure assessment, and Chapter 6 guides users through the presentation of results.

Other Key EPA Resources (Slide 32)

- The Guidelines for Exposure Assessment is not the only resource to rely on when planning and conducting an exposure assessment. The remaining courses in this EXA series will cover not only the Exposure Assessment Guidelines, but other key EPA resources including:
  - EPA-Expo-Box http://www.epa.gov/risk/expobox/
  - Exposure Factors Handbook (U.S. EPA, 1997)
  - Child-Specific Exposure Factors Handbook (U.S. EPA, 2008)
  - Example Exposure Scenarios (U.S. EPA, 2004)
  - Risk Assessment Guidance for Superfund (RAGS)
  - Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants (U.S. EPA, 2005)
  - Dermal Exposure Assessment: Principles and Applications (U.S. EPA, 1992a)
- Additional resources on the topic of risk assessment are also available from EPA – this is only a partial list.

EXA Course Series (Slide 33)

- We will continue our discussion of exposure assessment in the next nine courses. We will discuss how to quantify exposure and develop exposure scenarios to allow us to calculate dose.
- We will follow a chemical from source to receptor by exploring fate and transport and monitoring and modeling strategies.
- Then we will talk more about exposure factor data and how we describe uncertainty and variability in our assessments. We will discuss the use of biomonitoring data to improve exposure assessments.
- In the last two courses, we will put these concepts into practice in two case studies, one on lead exposure and the other dealing with dioxin.

- So the basic concepts of exposure assessment that we have introduced over the last 45 minutes will be repeated and reinforced as we move through the next nine courses.

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