A chemical can change the message

An endocrine disruptor is a chemical that interferes with an animal's hormone system. Its defining feature is disruption of signaling, not an odor, visible pollution or immediate death.

1. NORMAL SIGNALING: SEND, RECOGNIZE, RESPOND

ENDOCRINE GLAND

Releases a hormone into circulation.

→

TARGET RECEPTOR

Recognizes the matching hormone.

→

CELL RESPONSE

Changes activity or gene expression.

Hormones coordinate growth, metabolism, development and reproduction. Many cells encounter a circulating hormone, but a response requires the appropriate receptor. Receptors may be on the cell surface or inside the cell.

2. THREE WAYS TO DISRUPT THE SIGNAL

A. MIMIC

A chemical activates a hormone receptor, triggering a response at the wrong time or with an inappropriate strength.

B. BLOCK

A chemical prevents a hormone from producing its normal receptor-mediated response, weakening or stopping the message.

C. ALTER LEVELS

A chemical changes hormone production or other processes controlling hormone availability, so too much or too little signal reaches targets.

3. DIFFERENT FROM SIMPLE PHYSICAL DAMAGE

Sediment can block light and litter can obstruct an intestine. Endocrine disruption instead changes biological communication. One chemical can have more than one harmful action, so identify the hormone-related mechanism rather than assuming every toxic effect is endocrine disruption.

Normal glands, hormones and receptors: US EPA, Overview of the Endocrine System.
Mimicry, blocking and hormone levels: US EPA, Overview of Endocrine Disruption.

Scope: College Board AP Environmental Science CED, Topic 8.3, p. 160.

Connect the chemical to exposure

Endocrine-disrupting chemicals can be natural or human-made. A useful explanation names a chemical or chemical group, identifies an exposure route and connects it to a hormone-related effect.

1. EXAMPLES THAT MAKE THE IDEA CONCRETE

BISPHENOL A (BPA)

Used in some polycarbonate plastics and epoxy resins, including some food-container linings.

SOME PHTHALATES

Used as plasticizers and ingredients in certain consumer products. This is a group of chemicals, not one substance.

SYNTHETIC ESTROGENS

Hormone-active pharmaceuticals can enter wastewater. Some effluents contain estrogenic substances that expose downstream fish.

These examples do not mean every plastic, pesticide or medicine has the same endocrine activity or environmental risk.

2. LOW CONCENTRATION DOES NOT MEAN NO EFFECT

Hormones normally act in small amounts, so some disruptors can affect sensitive signaling at low exposure levels. That does not mean every detectable amount inevitably causes harm. The chemical, dose, exposure duration, organism and developmental stage all matter.

3. TIMING CAN CHANGE THE OUTCOME

Hormone signals guide development as well as adult function. Interference during a sensitive developmental period can produce lasting abnormalities or later reproductive problems. A lack of immediate mortality does not establish that development or fertility is unaffected.

Chemical examples and small hormone signals: NIEHS, Endocrine Disruptors.
Development and reproductive effects: US EPA, Overview of Endocrine Disruption.
Estrogenic substances in wastewater: Kidd et al. (2007), PNAS.

Scope: College Board AP Environmental Science CED, Topic 8.3, p. 160.

From altered hormones to populations

Core effects include developmental abnormalities, impaired reproduction and changes in the balance of biological sexes in fish and other animals. Not every chemical causes every effect in every species.

1. FOLLOW A POSSIBLE POPULATION-LEVEL PATHWAY

INDIVIDUAL

Altered reproductive development or fertility.

→

RECRUITMENT

Fewer offspring survive to join the population.

→

POPULATION

Numbers can fall when losses exceed additions.

This is a possible causal chain, not an automatic outcome of every exposure.

2. EXTENSION: A WHOLE-LAKE EXPERIMENT

Kidd and colleagues (2007) studied a Canadian lake exposed to the synthetic estrogen EE2. Additions during 2001-2003 produced concentrations of about 5-6 ng/L. Fathead minnows showed altered reproductive development, and the population nearly disappeared from that lake.
The study links hormone-related effects to population sustainability. It does not show that all fish species respond identically or that this concentration is a universal threshold for every disruptor.

3. EXTENSION: READ THE UNITS CORRECTLY

A nanogram is one-billionth of a gram.
5 ng/L = 0.005 micrograms/L = 0.000005 mg/L
These are equal concentrations, not different exposures. A small numerical value alone cannot establish either safety or harm.

Keep the evidence specific: altered sexual development is not the same measurement as a changed sex ratio. To establish a population effect, examine reproduction, recruitment and abundance over time, not just the appearance of one animal.

Required effects: College Board, STB-3.C.1 and STB-3.D.1.
Case study: Kidd et al. (2007), PNAS 104:8897-8901, doi:10.1073/pnas.0609568104.

Scope: College Board AP Environmental Science CED, Topic 8.3, p. 160.