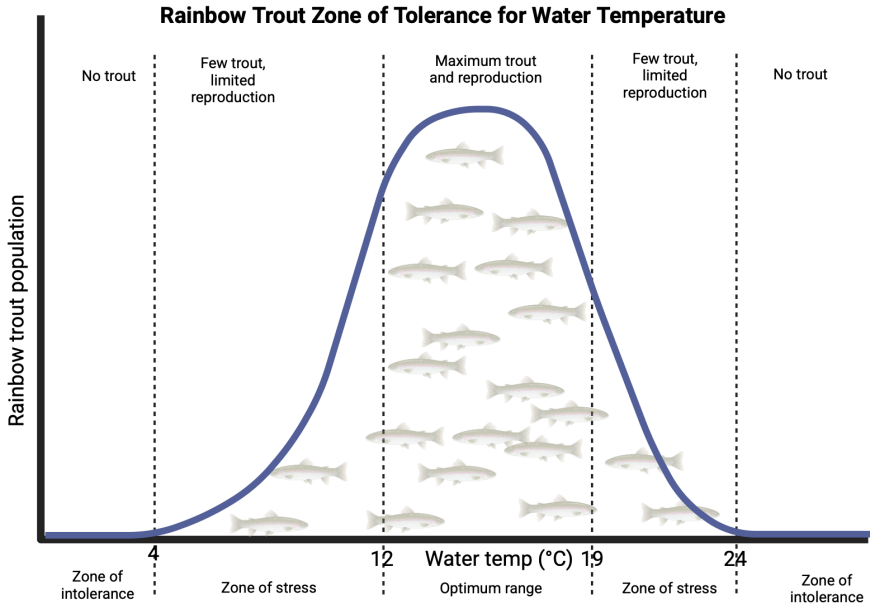
Unit	Trout Biology
Lesson	3.3 Measuring abiotic requirements for trout
Essential question	What abiotic parameters do trout require to thrive?
Objective	Students will be able to identify and measure the abiotic parameter required for trout habitat.
Key words	Zone of tolerance, pH, dissolved oxygen, eutrophication, biological oxygen demand (BOD), oxygen sag curve
Related Standards	
NGSS standar	HS-LS2-2
AP Env Sci topi	2.4
IB Biology topic	B4.1
IB ESS topi	2.1
Suggested sequenc of learning activities	1. Starter quiz/prior knowledge check 2. Direct instruction (if traditional) or classroom discussion (if flipped). Slides here. 3. Students conduct DO investigation, student sheet here. 4. Students do Oxygen Sag Curve analysis questions here. Answers by request 5. Individual exit ticket/comprehension check If you have access to a stream with your class or at least yourself t collect stream samples, could do BOD investigation, student sheet here. Answers to prelab questions by request
Assessment	Exit ticket/comprehension check
Possible modifications	● Give a keyword list (with or without definitions already included) to students before or during class ● Be intentional about student groupings (eg. heterogeneous skill levels)

Resources required	For DO investigation: One water sample tube (with cap) per group, DO measurement device (either electronic probe or chemical test), water, electric kettle, ice cubes/ice water, hard copies of DO investigation student sheet found here. For BOD investigation: water collected at a stream, DO measurem device (either electronic probe or chemical test), at least 2 water sample tubes (with caps) per group, hard copies of BOD investigati student sheet found here. For Oxygen Sag Curve analysis questions, hard copies or digital ac to this.
Starter questions	1. What are three abiotic factors that determine whether trout can live in a stream? 2. Choose one of those factors and identify two ways that huma activity could affect that factor.
Concepts covered in lesson	We learned earlier that an ecosystem is a community of living thing (biotic factors) interacting with the non-living components (abiotic factors) of a specific area. Each species has a **zone of tolerance** for each abiotic factor that contributes to whether a species is present how large is the population. For example, each species of trout has zone of tolerance for temperature, pH and dissolved oxygen. For each abiotic factor, a species has zones of intolerance below a above extreme levels at which those organisms die or have to flee. less extreme higher or lower levels, the organisms are under stress may not reproduce or grow robustly. In the middle, there is an optimum range where there will be maximum population and reproduction. See example graph below of the effect of temperatur on rainbow trout population.



Besides temperature, trout have a limited tolerance of **pH** in their water, a measure of acidity/alkalinity that ranges on a logarithmic s from 1 (very acidic) to 7 (neutral) to 14 (very basic or alkaline). Aci mine drainage from abandoned hard rock mines often negatively af trout populations as the wat r becomes too acidic (below 5.5). Some trout streams, called limestone or chalk streams, flow through limestone bedrock which increases the pH of the water to as high a 8.0 as calcium and carbonat ions dissolve in the water. This alkaline water contributes to robust plant and macroinvertebrate growth leading to healthy trout populations.

Another abiotic factor important to trout is **dissolved oxygen** (DO) which trout use their gills to oxygenate their blood. DO enters the water from atmospheric oxygen which has a relatively higher proportion of oxygen. DO absorption rates are increased when turbulence introduces air bubbles into the water, like at a waterfall. DO also enters the water as a product of photosynthesis by aquatic plants. In addition, cold water can hold more DO than warm water. Trout generally need DO levels of at least 5 mg/L.

As previously discussed, **eutrophication** is a type of pollution where excess nutrients cause an algal bloom which decomposes and use all the DO in a waterway, causing anoxic (low DO) conditions. A

	measure of how much DO would be required to decompose the organic matter in a sample of water is called **biological oxygen demand** (BOD). Water with high amounts of organic matter will ha a high BOD which potentially could lead to low DO levels and stres on fish and other aquatic animals. An **oxygen sag curve** is a graph showing the DO readings in a stre below a source of organic pollution. The DO is lowest directly belo the source where the BOD is highest. DO increases downstream a BOD decreases due to dilution and decomposition of the organic pollution. Fish and macroinvertebrate sampling can show lower populations where BOD is high and DO is low with populations rebounding downstream.
Slide presentation	Link here
Activity	DO investigation student sheet found here. BOD investigation student sheet found here.
Exit ticket questions	1. What factors can increase the dissolved oxygen (DO) of a tr stream? 2. What could be a reason that a stream might have a high biological oxygen demand (BOD)? Answers: 1. *Cold water and turbulence (air bubbles in the stream)* 2. *Many reasonable answers possible, including organic pollut from a sewage treatment plant or runoff from a farm (fertilize or animal waste)*

Extension questions/activities/ resources	Could also do acid rain lab with vinegar and chalk. Have students research acid rain causes, effects and how it was mitigated in the United States through the Clean Air Act. Have students research how trout and salmon change their physiol to switch from living in fresh water to salt water and back. Consider participating in the Trout in the Classroom (or Salmon in t Classroom) program from Trout Unlimited. Students raise trout in a classroom tank and measure water chemistry throughout. Details here.