Heat & Heat Sources

What is Heat?

According to the dictionary there are several definitions as follows:

- The degree of hotness or coldness of a body or environment.
- A measure of the warmth or coldness of an object or substance with reference to some standard value.
- A measure of the average kinetic energy of the particles in a sample of matter, expressed in terms of units or degrees on a standard scale.
- A measure of the ability of a substance, or more generally of any physical system, to transfer heat energy to another system.
- Any of various standardized numerical measures of this ability, such as the Kelvin, Fahrenheit, and Celsius scale.

What is Temperature?

Temperature is a measure of the ability of a substance, or more generally of any physical system, to transfer heat energy to another physical system. The higher the temperature of an object is, the greater the tendency of that object to transfer heat. The lower the temperature of an object is, the greater the tendency of that object to be on the receiving end of the heat transfer (classroom.com)

Why is Heat so Important?

Reptiles are ectothermic, also known as cold blooded, meaning they cannot produce body heat themselves and have to rely on the temperature around them in order to regulate their internal body temperature. Heat is a form of energy and different bodily functions require different levels of energy, for example breathing requiring less energy than running. By means of thermoregulation the animal is able to control how much energy is stored for future use, provided they have access to a proper thermal gradient with ample available energy.

It is important to think of heat as energy, as that is both what it is and what it provides. Similar to how we think of light providing energy to plants (although light provides energy to animals too) heat is another form of energy provided to all living things. This energy can be absorbed, stored, and used for various bodily functions such as digestion, mobility, shedding, general health, and so on. As mentioned above, different functions require different levels of energy, there are even some medical treatments used for parasites and worms that require specific temperatures to be effective.

This file aims to better explain the different wavelengths of heat and how each provides different levels of energy, and to better explain why we suggest the things we do given the current information on hand. Without heat, there isn't energy. Without energy, the animal simply cannot survive. Our goal is to provide ample energy with options that allow the animal to choose when, where, and how much of this energy they receive at any given time.

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What are the Different Types of Heat for Our Use?

Our normal heat is made up of **Wavelengths** such as **Infrared(IR) A/B/C** and each one will act differently and measured in Nanometers(nm) We will provide a basic breakdown but will get a bit more scientific. But take your time, if you understand this the question of what heat is best will be easy to answer for you.

When we are talking about heat we are talking about **infrared-wavelength**. On the spectrum below you can see that Infrared is the area right before the visible light.

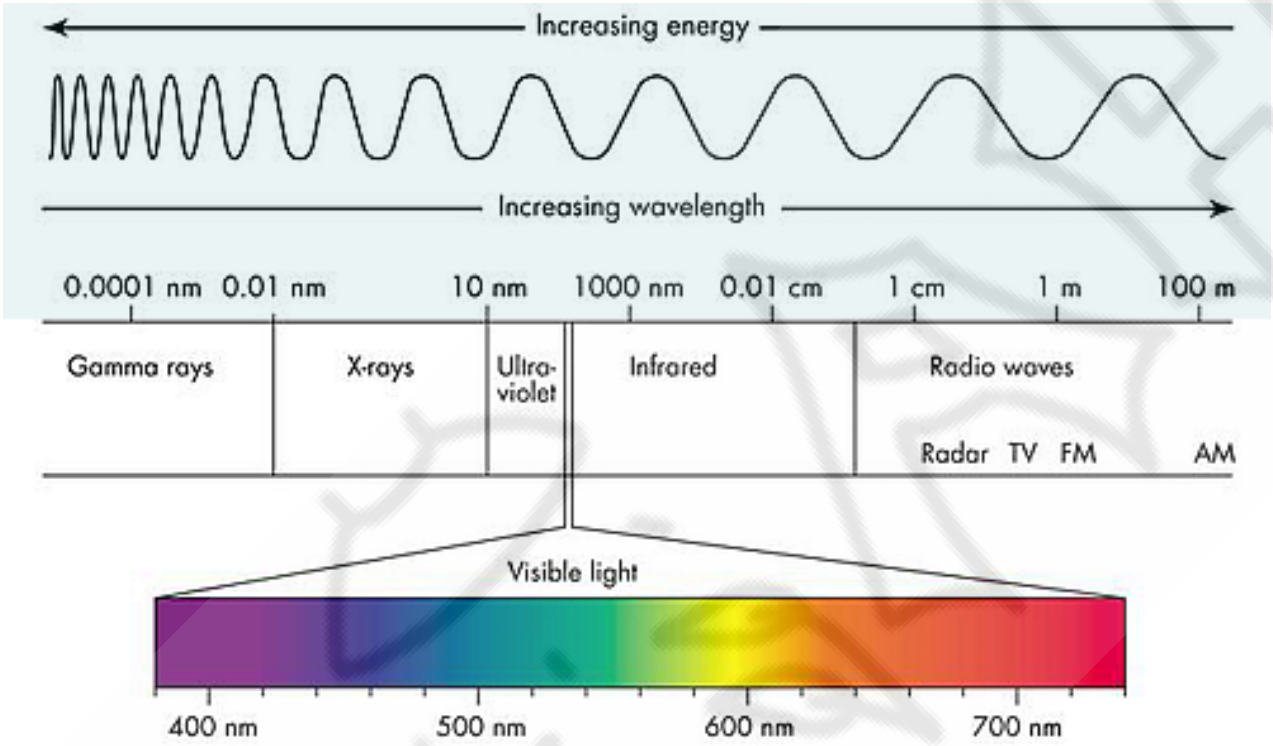

Image source: https://www.cyberphysics.co.uk/topics/light/emspect.htm

As previously mentioned infrared-wavelengths are divided in 3 areas Infrared-A, B and C.

Infrared-A has a wavelength of 780-1400 nm. This short wavelength is able to penetrate roughly 4-5mm deep into the subcutaneous tissue which is roughly 40-50 times deeper than IR-C. Here you really achieve the “deep heat”.

Infrared-B has a wavelength of 1400-3000 nm. It can penetrate roughly 1-2mm deep in the epidermis.

Infrared-C has a wavelength of >3000 nm. It can penetrate roughly 0-1mm. In humans this is only the corneum, the first layer of the skin.

To the right is a graphic that might help you understand the different depth of penetration. Notice how much deeper the Infrared-A wavelength is penetrating compared to the Infrared-C wavelength.

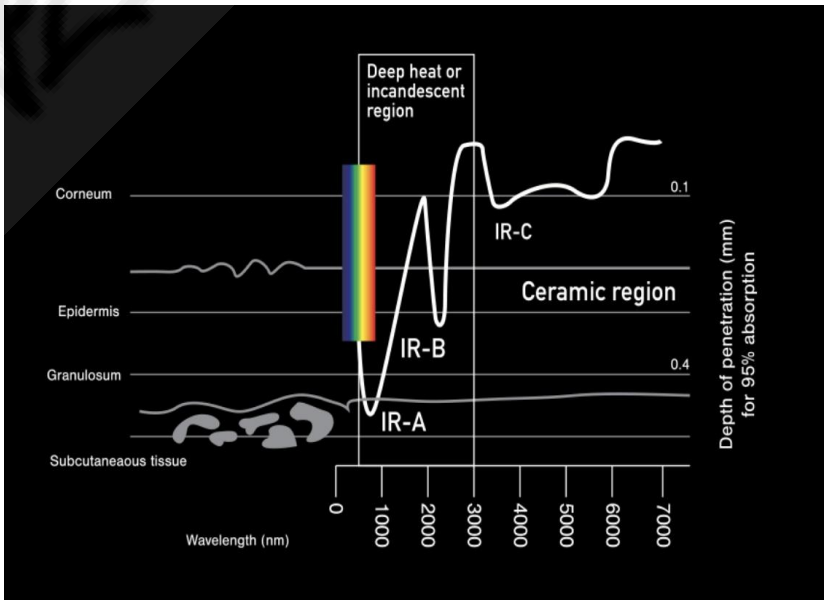

Image source: https://www.arcadiareptile.com/heating/heat-projector/

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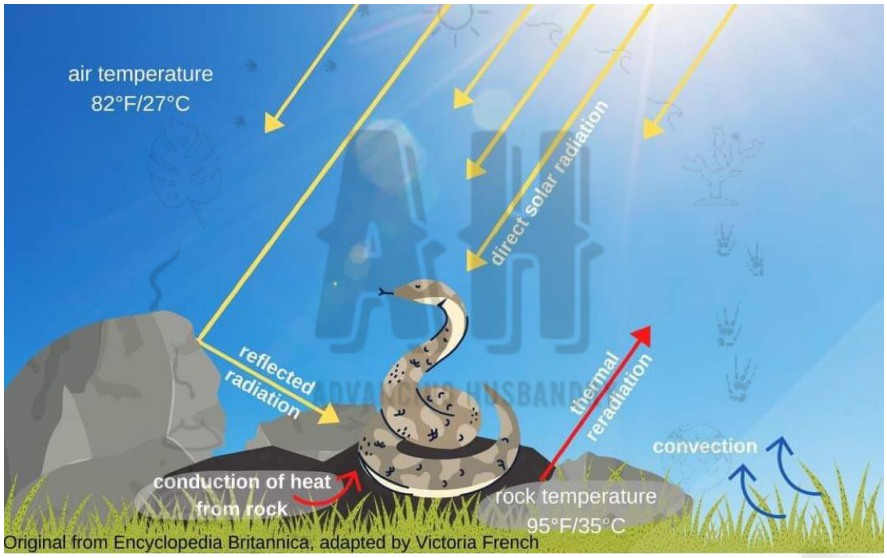


In nature the sun projects IR-A and IR-B downwards which then reflects off of various surfaces and is absorbed by black bodies. The black bodies then release thermal radiation outward as IR-C. Conduction is when a black body storing heat comes into contact with a cooler object (such as a snake) and then the two objects exchange energy back and forth in an attempt to reach an equilibrium. Convection is when energy comes into contact with water particles in the air, reflecting off some and causing others to heat until evaporation. This is what helps raise ambient temperatures. Direct solar radiation, reflection, conduction, thermal radiation, and convection all contribute to full body warming.

The reptile can then thermoregulate by using various methods to cool down such as moving to somewhere more shaded, burrowing, wading in water, tongue flicking, panting, changing its color, and so on.

What Heat Sources Provide Which Wavelength?

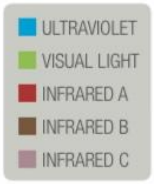
Quick caveat before you read below. When you go outside in the summer from your air conditioned house and stand in the sun you will notice you get a nice tingly feeling over your body, as it feels good. This is the IR-A and IR-B heat wavelengths penetrating your skin. If you hold your hand above a parking-lot blacktop or rock that's been sitting in the sun, the warmth you feel is IR-C, which you are only feeling on the very surface of your skin.

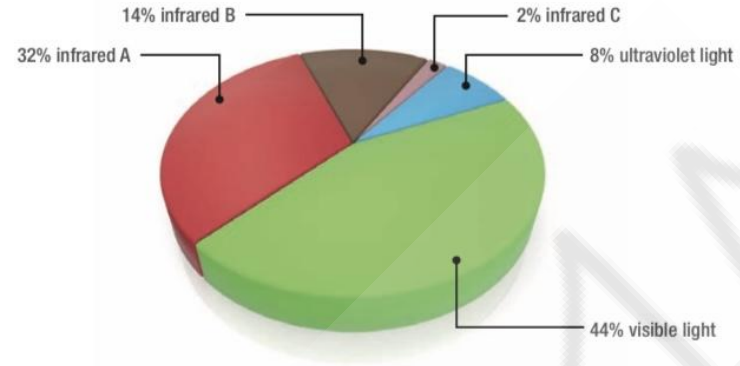
Different heat sources emit different types of IR wavelengths based on how they create the heat that they emit. For example, any heat source that uses a conductor will emit primarily IR-C as the conductor will heat a black body which then radiates thermal energy outwards as mentioned previously (e.g. a heat mat uses a conductor to heat the mat material, a ceramic heat emitter heats a ceramic bulb, etc.), however a heat source that uses a current that runs through a filament that then heats a gas surrounding it can emit shorter IR wavelengths, therefore offering IR-A and/or IR-B.

Roman Muryn is a physicist with a focus on reptiles who has greatly helped the community in various ways such as providing leading research in regards to heating and lighting for our scaly friends. He has tested various sources of heat and their output to better understand IR and how we can apply our knowledge to reptile keeping. Below is a diagram that he has shared showing his test results of some of the most commonly used heating devices in our enclosures and how they compare to the ratio of IR released by the sun. These readings are of the sun, a Tungsten-Halogen Iridescent Lamp, a Heat-Projector Carbon Filament Lamp (also known as a Deep Heat Projector or DHP), and a Ceramic Heat Emitter (also known as a CHE) respectively.

Sunlight

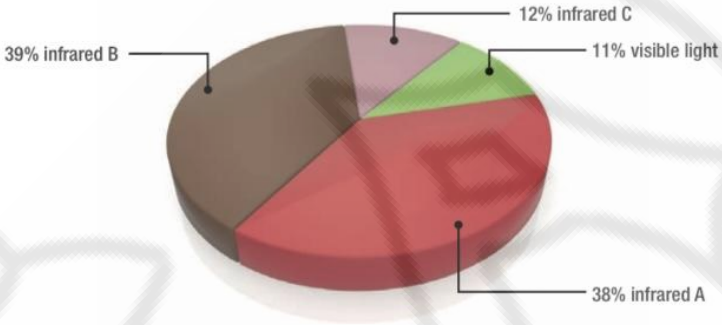
- 8% is ultraviolet light
- 44% is light visible to human eyes
- 32% is infrared A
- 14% is infrared B
- 2% is infrared C





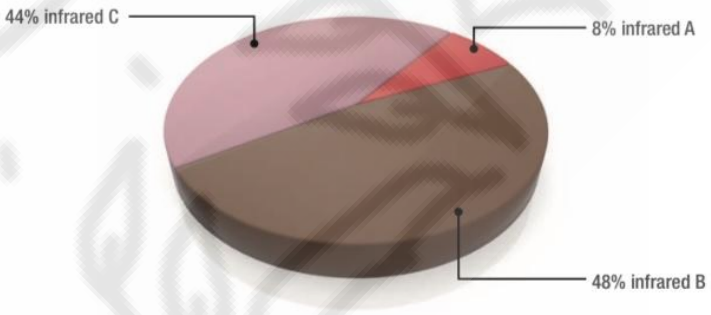
Tungsten-halogen incandescent lamp

- no ultraviolet light
- 11% is light visible to human eyes
- 38% is infrared A
- 39% is infrared B
- 12% is infrared C



Heat-projector carbon filament lamp

- no ultraviolet light
- no light visible to human eyes
- 8% is infrared A
- 48% is infrared B
- 44% is infrared C



Ceramic heat emitter

- no ultraviolet light
- no light visible to human eyes
- no infrared A
- 1% is infrared B
- 99% is infrared C

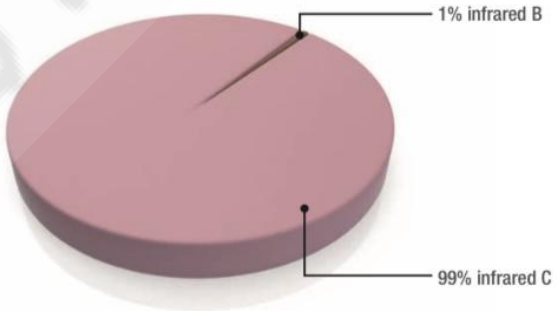


Image courtesy of Roman Muryn from Next Level Heating: Why InfraredWavelengths Matter

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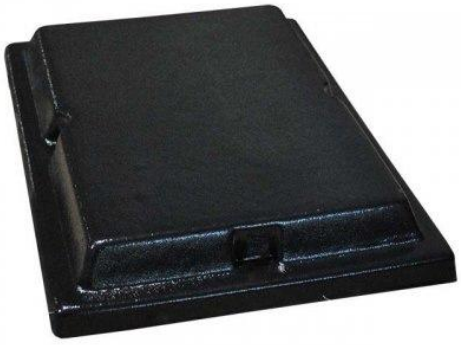
Using the information provided above we can now figure out which healing options provide the most natural and efficient IR wavelengths.

Halogen bulbs provide primarily IR-A, some IR-B, little IR-C, as well as visible light. This is the closest to the sun's heat that we are able to provide. Once this heat is absorbed and then reflected from the ground or rocks it produces IR-C. IR-A and IR-B wavelengths are directional so they are able to produce more natural and balanced ambient temperatures. This is the absolute best option for accomplishing an ideal temperature gradient.
***This is the most ideal choice.**

Deep Heat Projectors (DHPs) provide primarily IR-B, some IR-C, very little IR-A, and next to no visible light (4 Luxe on max.) Once this heat is absorbed and then reflected from the ground of rocks it produces IR-C, the same as a halogen bulb. IR-B heat waves are directional so it also produces more natural and balanced ambient temperatures.

***DHPs are the second best choice for creating ideal temperatures, but we do highly recommend using a heat source that produces visible light.**

Heat Mats, also known as Under Tank Heaters (UTH), Ceramic Heat Emitters (CHE), and Radiant Heat Panels (RHP) produce IR-C. IR-C is a non-directional wavelength that would **rarely be found as a sole source of day time heat in a leopard gecko's natural habitat**. A UTH would have to be used on the back or side of the enclosure and would have to be insulated in order to raise ambient temperatures, **and this is extremely dangerous with most brands of heat mats**. CHEs and RHPs can raise ambient temperatures in a safe manner, but the heat they produce does not function similarly to the sun and burns off moisture in the air very quickly, often rapidly lowering humidity levels. **For this reason, we do not recommend using an RHP, they often heat more of the enclosure than a single CHE bulb would.** We also recommend to never use a CHE as your daytime heat source, but they can be used at night if temperatures drop below 65°F since they do not produce light.



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How Do You Control Heat Sources?

Every heat source you use must be dimmed down in order to get ideal and, more importantly, **safe** temperatures. The best option for this is a dimming thermostat. A thermostat is a device that measures the temperature constantly and adjusts the output of the heat source either by raising or lowering its power supply, or turning it on or off if it gets too cold or too hot; this depends on the type of thermostat used. A thermostat is different than a manual plug-in dimmer or dimming switch not only for its ability to self-adjust but also due to added safety benefits such as an automatic shut off in the case of a power surge (to avoid your heat source from getting damaged), or if faulty equipment is detected (to avoid temperatures rising to a dangerous level).

For any light emitting heat source as well as DHPs you will need a **dimming thermostat**. This will dim the heat source as needed by reducing the amount of electricity flowing through the bulb to achieve a steady temperature. An On/Off or Pulse thermostat is not recommended with Halogen bulbs or DHPs and can lead to sudden, premature failures as these work by turning the heat source off once the desired temperature is reached and then back on when it drops too low. With a light emitting heat source (such as a halogen) the light would strobe, which would then cause a lot of stress for the leopard gecko.

Another good but less reliable option is a **plug-in dimmer**. This allows you to manually adjust how much heat your bulb is putting off, but this **will not regulate the temperature for you**. This means that you will have to monitor your temperatures regularly using reliable thermometers and an infrared temperature gun and adjust the dimmer as necessary. When using this method, temperatures should be checked multiple times per day, but usually as long as the room the gecko is in does not fluctuate adjustments will not be needed (**but you still must double check**).

What Wavelengths are Needed for Leopard Geckos?

If possible all wavelengths should be provided, but you definitely want IR-A short wavelength and IR-B medium wavelength. The IR-A specifically is important as only then can the leopard gecko adequately control its body temperature. Having only IR-C long wavelength present wouldn't be proper or enough as a heat source as it is not deeply penetrating nor similar to the sun, offering poor quality heat to the animal.

Using Lighting with Captive Animals

When using lights, either for heat, for UV, or for both, it is important to install them based on the **Light-Shade Method** (also referred to as the **Sunbeam Method**.) In nature warmth and light come from a single source, the sun, so it is important to replicate this in captivity. Here you basically have heat and light in one zone and the other zone is cool and shaded.

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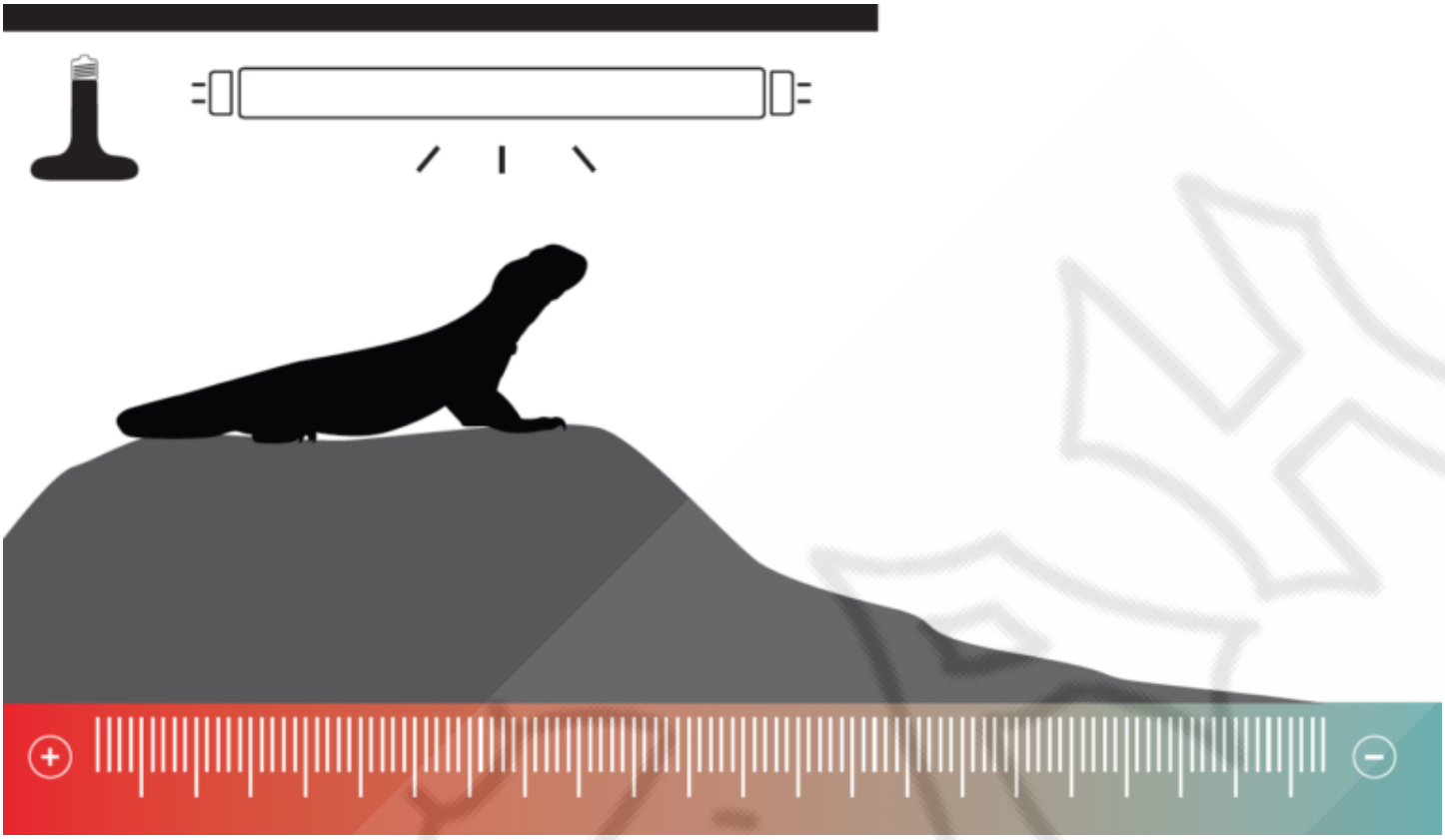
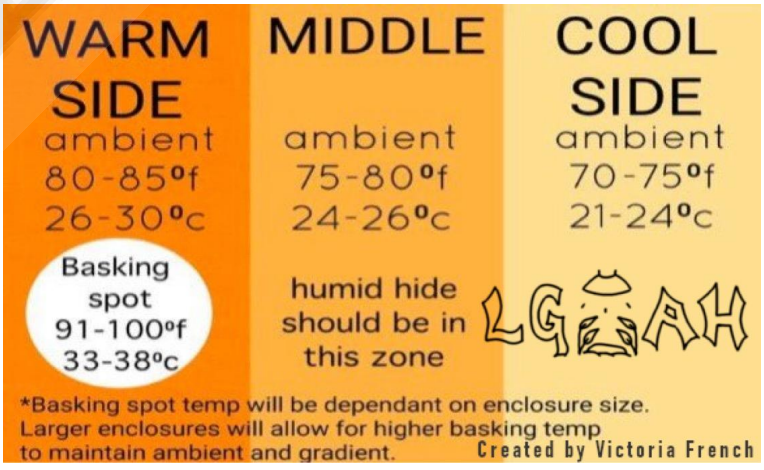


Image source:
https://www.arcadiareptile.com/light-shade-method/

Now when it comes to heat, you can't just heat up the whole enclosure until it reaches a specific temperature as this does not provide the aforementioned gradient. In the wild a leopard gecko would have the option of hiding away in their burrow for cooler temperatures, as they often do during the day, or hiding in shaded or more open areas for warmer temperatures. This is why it's important to provide a gradient, as it allows the gecko to self regulate its temperature as needed. **The specific numbers of these provided temperatures are important**.

This would be an example of a gradient from warm to cool, with a basking area directly below the heat source. As you can see the temperature should gradually taper from the hotter temperatures on one side to the cooler temperatures on the other. It is recommended to keep a gradient of roughly 10°F/6°C between the two sides to allow for proper thermoregulation.

However in enclosures that are 5'/153cm or more, it is recommended that there be two hot spots so as to allow the animal easy access to heat at all times. Example below.



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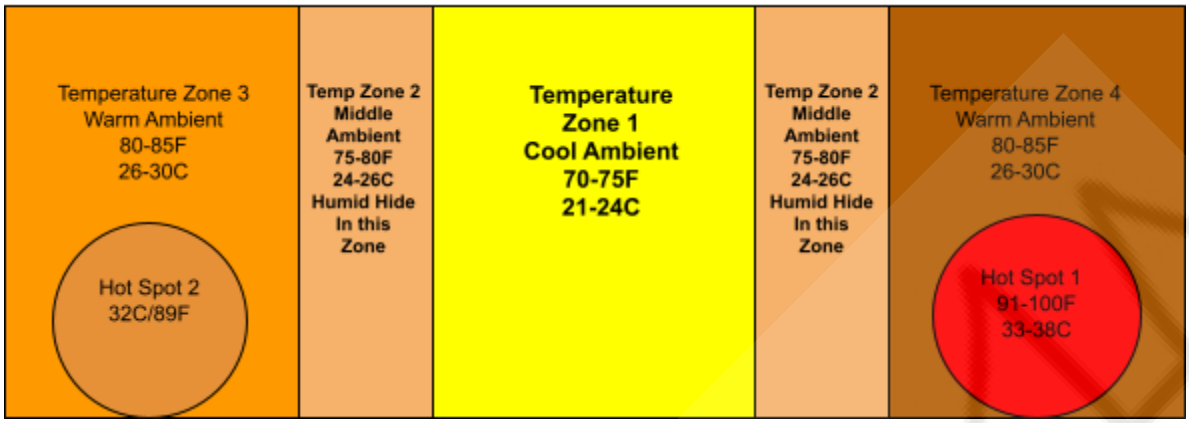

Nighttime Heat

At night a temperature drop is not only beneficial, but also very natural and is a great way to aid in a healthy **Circadian Rhythm** (also referred to as a day and night cycle.) For nighttime you want temperatures of 18°C/65°F or higher. If your house gets cooler than that you can use a DHP or CHE to boost your ambient temperatures a bit as they are non-light emitting as previously mentioned.

Using non light emitting heat sources for night time temperatures is very important as light of any kind greatly disturbs their circadian rhythm. Red bulbs for example are commonly marketed for night time use under the misconception that reptiles cannot see the color red, when in reality a great number of reptiles not only have full color vision, but are actually able to see color much better than humans. When you use a colored bulb it washes the animal's vision in the color provided, robbing them of their full color vision. This can then lead to confusion, disorientation, and constant low levels of stress. Reptiles have this amazing color vision in order to exercise good depth perception and to easily distinguish their environment. Below is an image to better show how a red bulb can wash everything in red.

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Image courtesy of Frances Baines of Reptile Lighting. Pictured is her own Sceloporus Serrifer Cyanogenys

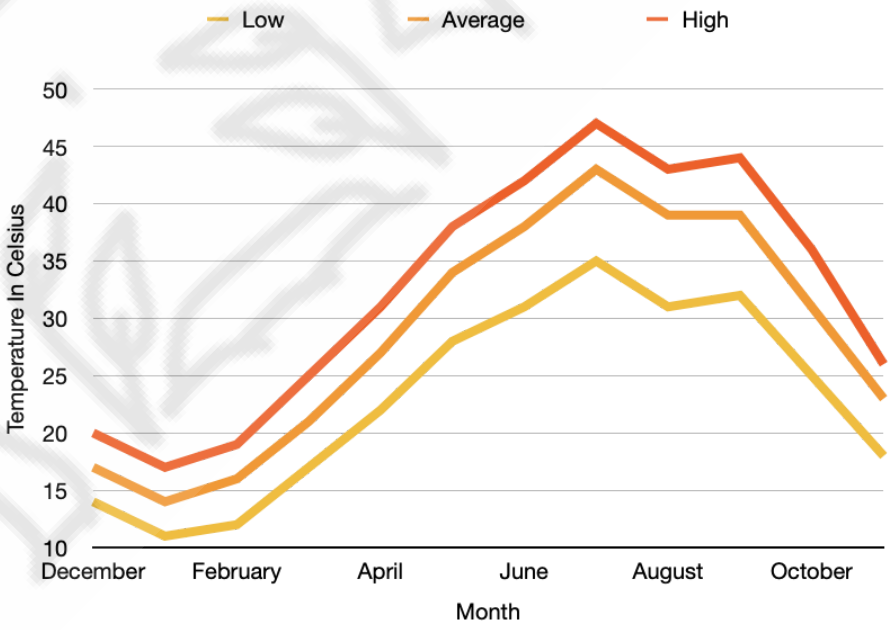
Even if they couldn't see color they very much can see light, and are again usually more sensitive to it than we are. Blue Moonlight Bulbs are commonly marketed as well as a way to better replicate the light of the moon. In reality the moon does not emit light but instead reflects light from the sun. This means the light you see from the moon is a warm yellow light, and is in incredibly low levels. So low that we have not yet been able to create any stand alone bulb that can recreate the incredibly low levels of light the moon provides. **If you can see light coming from the bulb, then so can your lizard and it is much too bright.**

Blue light specifically is especially bad as high levels of blue light have been directly linked to vision loss and blindness as they bleach the retinas of the animal. While moonlight bulbs are not high levels of blue light they can still cause physical damage if your animal is unable to look away from it for whatever reason, such as a neurological disorder. Another thing to note about blue light is how it is the type of light the brain uses to signify day time. This is why health experts advise you not to use electronics before bed as the blue light they emit makes it harder for you to not only fall asleep, but also maintain a healthy, deep sleep. Blue light has the same effect on reptiles and this is why they are actually much worse than other colored bulbs when it comes to disrupting the animal's circadian rhythm.

While leopard geckos are primarily active at twilight and throughout the night this does not mean that they benefit from any sort of added light as naturally they would not have that. With so many non-light emitting heat options out there, there just isn't any good reason to use colored bulbs.

In Summary

The temperature can be as high as 116°F/47°C in their natural habitat. To the right is a chart showing these temperatures of Baghdad, Iraq from December 2019 to November 2020, one of the many places leopard geckos can be found in the wild. This shows that they're able to experience higher, and lower, temperatures than what we typically provide for them in captivity. It's truly amazing just how much we have come to learn over the years about heat and how it interacts with creatures, and now know that heat is more than just a compilation of numbers and ranges to be achieved. What heat source you use, what wavelengths are emitted, and how the enclosure itself is set up greatly impacts your reptile. By providing light emitting heat sources with a high IR-A ratio we are able to better replicate their natural habitat, offer better penetrating heat, and ample energy.



Halogens and other incandescent bulbs are the closest source to the sun in terms of IR ratio and visible light. DHPs are a second best option. UTHs are subpar and only recommended for temporary use such as quarantine or emergencies. No heat is needed at night unless temperatures drop too low, and in that case a non light emitting heat source such as a DHP or CHE is better to avoid disruption of their circadian rhythm.

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Sources Used:

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