Next level heating

Why infrared wavelengths matter

An interview with Roman Muryn C. Eng

For decades, providing heat for our reptiles has been a relatively simple affair. However, new research is changing the way we provide and measure heat, with a focus on wavelength rather than simply temperature. We spoke to researcher and herpetologist Roman Muryn about his work to understand heat and the infrared spectrum.

Your work seems to be opening a whole new chapter in the world of reptile keeping. What was it that made you first think about heating and infrared?

I'd kept turtles for many years and would often observe lesions and infections in the soft tissue when the turtles emerged from hibernation – especially lesions around the eyes. Of course, I was eager to prevent and cure these infections and tried all kinds of antifungal potions, but nothing worked. It wasn't until I put my Spotted Turtles into 'The Dome' that I saw any significant improvement.

The Dome is my dome-shaped greenhouse built from a UV permeable plastic which allows sunlight to penetrate. The Spotted Turtles' infections were cured in a matter of days and I wanted to know how this amazing recovery was possible. To cut a long story short, I eventually realised the curative properties of sunlight, and of UV and infrared radiation in particular. What was even more interesting was the fact that these processes and benefits were not being discussed in the herpetological world. I decided I needed to do something about that – and so here we are.

Is there anyone else doing similar work?

Not that I am aware of, but I should point out that I don't really do the work. I simply collect other people's research and ideas and test them with reptiles. I do bounce ideas back and forth with other herpers as I often get my inspiration during conversations. Many of my ideas have come as a result of conversations with the fantastic Dr Frances Baines. More recently Dr Sarina Wunderlicht, a lighting specialist from the DGHT German Society for Herpetology, has also been part of the loop. She adds a different perspective to the mix because of her formal optical work.

Where do you find your research information?

I often find information in papers that are unrelated to herpetoculture and then develop the connection to understand how the information can be used with reptiles. For example, I had been looking into glass transmissivity because I was trying to understand how keratin performed, when I found a paper on polar bears that showed how their fur provides insulation. From there I was able to link the glass greenhouse effect and keratin because they both work in similar ways. Since then other papers have described exactly how polar bears capture heat, and it's more ingenious than I first thought. I even sent keratin samples to Manchester University for transmissivity measurements, and the results stacked up with my hypothesis.

Why do reptiles bask?

Reptiles don't bask just to get warm or acquire UV. They bask for a whole host of reasons:

- for sheer pleasure
- for circadian cycle excitation through the parietal eye and pineal gland
- to capture D3 through UV irradiation
- to increase metabolism through warmth capture
- to use UV and infrared for managing fungal and bacterial infections
- to raise temperature to manage viral infections
- for wound healing
- for deeper heat penetration
- for internal egg and neonate incubation
- for digesting food
- for drying and heating to assist in shedding
- for parasite management

Let's look at reptile heating in captivity. What's wrong with how we've been doing it all these years?

The biggest issue is that people think of heat as heat – as if it is a single entity that they need to somehow provide in order to keep their reptile warm. However, most people don't realise there is a whole spectrum of infrared radiation wavelengths to consider.

We should think about heat in the same way we think about UV or visible light for reptiles. We tend to be very specific about the quality and type of UV light we provide. Similarly, many keepers are also considerate of the quality of visible light they offer too.

So, why don't we think about infrared radiation in the same way? We now know that providing infrared heat at the correct wavelengths is just as important because the different wavelengths provide for different physiological needs.

KEY TO TERMINOLOGY

NEAR-INFRARED (NIR)
OR INFRARED A (IRa)

MID-INFRARED (MIR)
OR INFRARED B (IRb)

FAR-INFRARED (FIR)
OR INFRARED C (IRc)

Can you explain what you mean by 'infrared' and 'heat wavelengths'?

The best way to explain it is to use the graph below, which shows the different types of light radiation emitted by the sun. All of the energy and heat we experience here on Planet Earth comes from the sun, and different organisms and lifeforms utilise these wavelengths in different ways.

The graph illustrates the three distinct wavelength groups emitted by the sun. On the far left of the spectrum is UV light. As humans, we can't see UV, but we know it's there, and we know it's important. Next along, you can see the visible light part of the spectrum.

This is the light from the sun which is absorbed by objects and reflected back to us as the colours we can see with our human eyes. As we know, many animals can see much more of the spectrum than us – some can see UV light and some can even see infrared wavelengths.

Which brings us a little further along the graph, where you can see the infrared wavelengths of the radiation spectrum. Again, as with UV, these wavelengths are mostly invisible to us, but we can feel infrared radiation as heat. As you can see, there's a whole spectrum of infrared radiation. There's not just one kind of heat being delivered by the sun. If you think about it in those terms, it makes perfect sense that we should be more discerning about the heat wavelengths we provide.

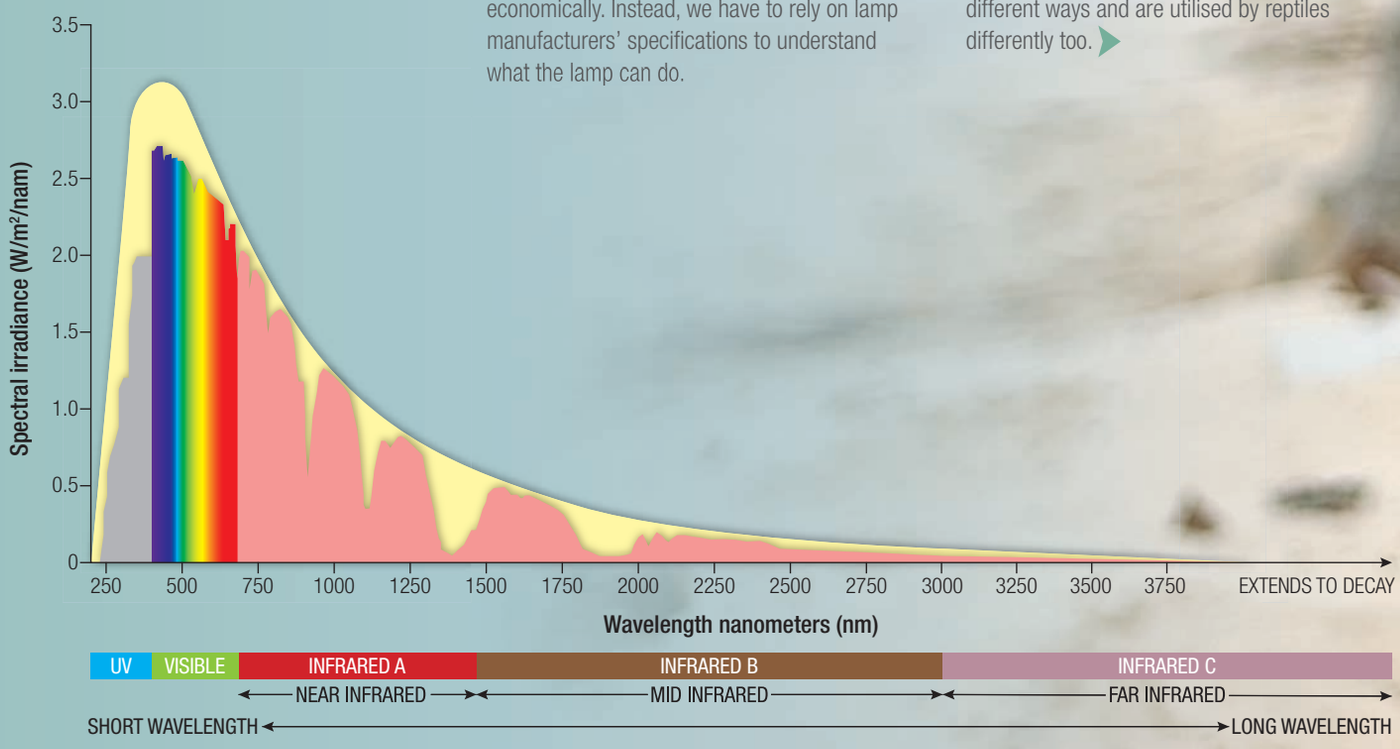
We are lucky that there are instruments and tools which enable us to test the quality of our UV lamps, and we can also measure visible light with a lux meter or a spectrometer. However, infrared cannot be measured easily or economically. Instead, we have to rely on lamp manufacturers' specifications to understand what the lamp can do.

It sounds like there's a lot to learn about infrared heat. Where do we start?

It's not easy to explain or understand, but let's start by thinking about the different types of heat we experience as humans. Let's imagine two different environments, both at the same temperature. The first environment is a warm room in your house, heated by radiators at 30°C. The second environment is a beach in a warm country, again, measuring 30°C.

While the temperatures are the same, the heat you feel while lying on the beach feels much different. You can feel the sun's rays on your skin and it warms your body right through, while the radiators seem to heat only your skin. You have to touch the radiator to see that it is working – you can't feel them from a distance.

This is a good place to start thinking about the types of heat we should be providing for our reptiles, because these different heat wavelengths quite obviously work in very different ways and are utilised by reptiles differently too.



The sunshine standard

Only the sun can provide all the radiation wavelengths necessary for reptile metabolism from a single source. In captivity we must use a variety of different types of heater to replicate this.

	INFRARED A (near-infrared) 700 – 1400 nm	INFRARED B (mid-infrared) 1400 – 3000 nm	INFRARED C (far-infrared) 3000 – 15000 nm
SOURCES	sun luminous heated body incandescent body tungsten or alloy filament	carbon heat emitter	non-luminous heated body hot rock electrical thermal radiator ceramic heat emitter
BODY PENETRATION	SIGNIFICANT: penetrates epidermis, dermis and subcutaneous tissue (5 – 10mm)	MODERATE	SUPERFICIAL: penetrates epidermis by less than 5mm
ABSORPTION	DEEP	MODERATE	SUPERFICIAL

I assume this is because each of these heat sources work in different parts of the infrared spectrum?
That's right. Take a look at the table above. It shows that infrared light radiation can be considered as three distinct types.

So you're saying we should be providing different types of heat for our animals?
Yes, absolutely. I believe we should be providing a choice of wavelengths so the animal can choose where on the infrared spectrum it wants to bask. We routinely provide a range of 'temperature' choices, and we also offer a range of different UV intensities and shade options.

In all of these circumstances we're endeavouring to replicate the availability of energy which would normally be acquired from the sun, so providing a spectrum of infrared heating choices is obviously important too.

In most indoor set-ups, reptiles don't have access to unfiltered sunlight, so keepers will need to use different types of heaters and lamps to achieve the same results. In essence, we should be providing various types of infrared radiation options for basking and background heat.

Let's start with NIR basking light and heat. What do we need to know?
NIR is radiation that we cannot see, and it is, strictly speaking, not heat. It is simply light that carries energy that can be efficiently absorbed and used by the body. The NIR spectrum begins with the just-visible dark red light at about 650nm and extends to 1400nm. This is the lovely orange-red light radiation you see coming from the embers of a bonfire or from the elements of a patio heater, but the short-wave radiation spectrum soon disappears from our human vision further down the spectrum.

The other benefit of NIR is that, having penetrated the tissue, the animal's blood vessels and other subcutaneous functions will also be positively influenced. This is what did the healing for my sick Spotted Turtle all those years ago.

Unfortunately, NIR is rather challenging to measure and expensive equipment is required. Nevertheless, this type of infrared radiation is exactly what we want a basking lamp to produce. NIR is admirably generated by incandescent lamps with colour temperatures around the 3000K region. It's worth noting that simply painting a film of colour on the front of a lamp does not achieve the same result.

What about FIR background heat?
FIR background radiation is measured as ambient temperatures throughout a vivarium. It is a low-grade heat operating at very long wavelengths. In nature, FIR heat is generated as a result of secondary re-radiation, such as from a rock, the ground, a piece of tin or some other object that has been heated by the sun. This can be simulated in a vivarium with a heat mat or a ceramic heat emitter.

There's clearly more to heating reptile enclosures than many people realise. How should we be approaching vivarium design with this in mind?

Before we talk of heating vivariums, we should make sure we understand how heat is generated. Right at the start of this interview, we discussed the fact that all energy comes from the sun. When any object is irradiated with sunlight, some of the energy is captured and stored by the object. The amount of energy stored depends on the object's absorption properties and colour. As the sun shines, its energy is absorbed and stored. Some is reflected back to our eyes as visible light, and some is re-radiated as heat.

Preventing burns

Reptiles that have suffered burns by 'basking' under their heat source for too long are not an uncommon sight for reptile vets. Often this is caused by reptiles being kept under long-wavelength heaters, such as ceramics, heat mats and some types of long-wave radiation lamps. These should never be used as the primary or sole source of heat for reptiles as they are not effective for deep-heating reptile tissue.

Reptiles will often sit under a ceramic heater for extended periods in an attempt to get warmed through. However, these heaters will only heat the animal's skin not penetrating deep enough to heat the animal internally – so the animal will sit there trying to warm itself thoroughly while its skin is being burned especially if the operating temperature is unnaturally high. To avoid this, an additional short-wavelength basking lamp is essential.

While the sun is shining the object will continue to absorb the radiation and get hotter until it reaches the point where the amount of heat received by the object is equal to the amount being emitted and lost to the environment – the object and the environment it is in are absorbing and emitting the same amount of energy.

As soon as the sun stops shining the object will start releasing the absorbed heat, albeit slowly and at a much longer wavelength than the original sunlight source. The object will continue to release this long-wave radiation until it reaches the environment's new, cooler ambient temperature. This is what happens with tarmac roads in the summertime, and that's why reptile hunting on roads is good after sunset. The animals that operate at night seek out the warm asphalt's energy in order to charge themselves up for the night's activity.

This re-radiating of energy produces a background heat. Some crevices amongst the rocks may stay warmer for longer, but the open flat surfaces soon cool down and, by morning, the cycle starts again. This happens not just daily, but seasonally. In the summer the ground will absorb more heat during the day than it can emit at night, so temperatures creep up and we get warmer summer days.

So what kind of heaters should we be using in reptile enclosures?
As mentioned previously, we should ideally be providing our animals with a choice of infrared radiation wavelengths, and that means using different types of heating and lighting lamps.

Incandescent lamps
Incandescent lamps, such as tungsten-halogen lamps, are good choices. They provide light by heating a tungsten filament to a white-hot temperature. These lamps do release visible light photons in the process, but some of the electrical power is used to make invisible NIR – and that's what we want to utilise for our basking reptiles.

In order to also provide longer wavelength far-infrared IRc, the addition of a ceramic or heat mat would be a good choice.

Why 'inefficient' lamps are better for basking

As visible light sources, most lamps are made to be 'efficient' – essentially aiming to give out more light and waste less energy producing heat. However, from a herpetological perspective, the less efficient an incandescent lamp is, the better it is for basking, because we're more interested in the heat output than the light.

Heat projectors

Heat projectors, such as the Arcadia Deep Heat Projector, produce FIR wavelengths, but almost no visible light. This makes these lamps ideal for providing heat at night without disrupting the light vs dark photoperiods which are necessary to stimulate breeding in some species.

To provide an effective basking spot with near-infrared IRa, the addition of a tungsten incandescent lamp would be a good choice

Ceramic heaters

Ceramics, heat plates, heat mats, and even underfloor heating can also be useful in many circumstances, particularly to provide FIR background heat at night or in large enclosures where ambient temperatures are not reaching the ideal range. These heating systems must be operated with careful consideration of their temperatures and allow the animals to escape to cool areas.

To provide near and mid-infrared IRa and IRb wavelengths for basking and night-time heat, the addition of incandescent lamps and deep heat projectors would be a good choice.

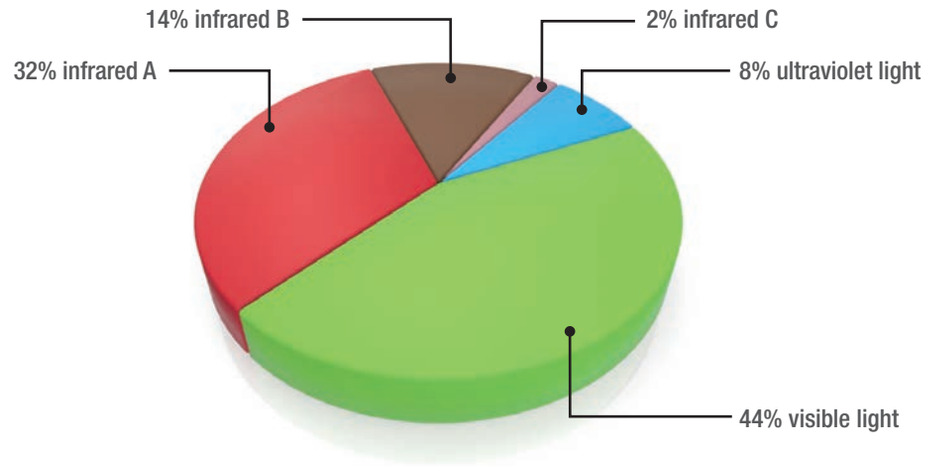
Stat choices

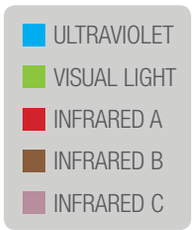
Some carbon-filament heat projectors on the market produce almost no light visible to the human eye. However, many reptiles can see the infrared radiation produced by these lamps because their retinal colour receptors can pick up the NIR spectrum. This is useful information when it comes to choosing an appropriate thermostat.

Pulse proportional stats are a bad choice when using this type of lamp. We humans may not see the lamp pulsing, but your reptile certainly will, and that creates a stressful environment with a flashing lamp that only your reptile can see. A dimming thermostat is a much better choice for this type of lamp.

Sunlight

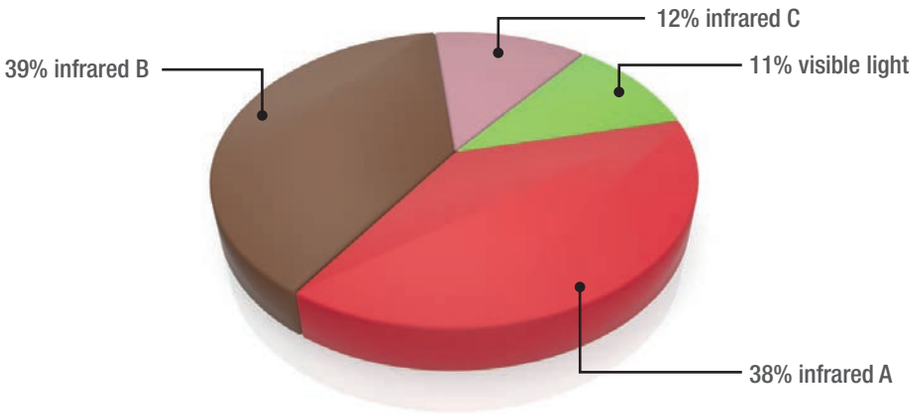
- 8% is ultraviolet light
- 44% is light visible to human eyes
- 32% is infrared A
- 14% is infrared B
- 2% is infrared C





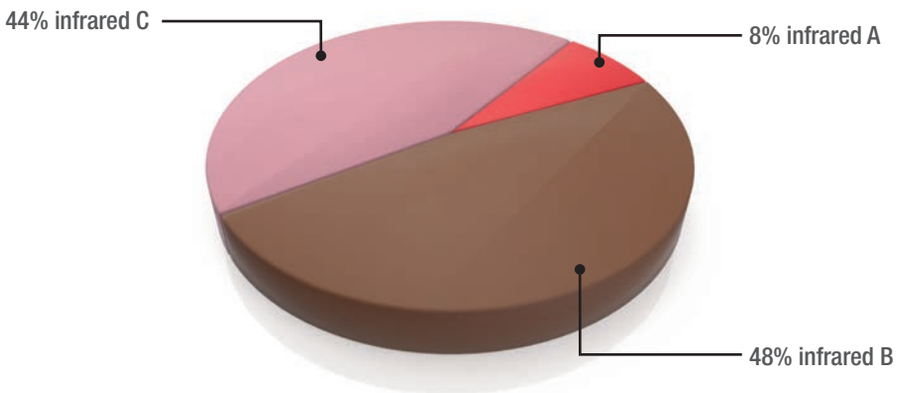
Tungsten-halogen incandescent lamp

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



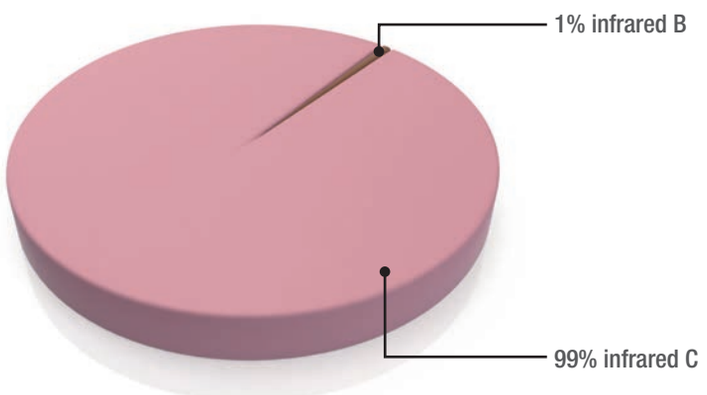
Heat-projector carbon filament lamp

- 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



What are the most common errors you see with reptile heating?
Undoubtedly, it's the way ceramic heat emitters are sometimes used within the hobby.

They're often used to provide basking spots, but these units emit far-infrared, and that's completely the wrong wavelength for this purpose. Sure, they'll provide surface temperatures which will look great when measured with a thermometer, but these far-infrared wavelengths simply cannot heat the animals effectively.

Ceramic heat emitters are good for providing background heat, much like you would get from tarmac roads or rocky landscapes after a hot day under the sun.

To do this effectively with ceramics, keepers should ideally use two or more units running at low-output temperatures, to provide background heat at different strategically chosen positions within the enclosure. This method is much more effective and suitable than attempting to use one ceramic unit pumping out high temperatures in an attempt to heat the whole enclosure.

After all, background ambient air temperatures are always much lower than basking temperatures. Bear in mind that, sometimes in the wild, the ambient temperature doesn't get warm enough for reptiles to metabolise effectively. This is where basking plays its part, as it is the most efficient way of safely getting the animals up to temperature using the correct wavelengths – ie near-infrared.

Ceramics are great for providing far-infrared IRc wavelengths at night, just as a sun-heated rock would in the wild, but they are not suitable to use as a singular heat source.

And should we be providing a full spectrum of light radiation across the whole spectrum, from UV to infrared?
In effect, that's exactly what we should be aspiring to do. We're aiming to replicate the effects of the sun as closely as possible, so it's less than ideal if we fail to provide radiation from a particular section of that sunlight spectrum. We talk about UV, heat and visible light as if they are separate things, but we should remember that they are all simply components of sunlight that work together.

There seems to be a lot to consider.
Yes, there is, but hopefully this interview will make it easier to understand and be useful to those stores that can use this information.
In short, these are the main points to consider:

- When choosing basking arrangements, start by selecting the lamp or lamps that provide the right wavelengths The most easily accessible and efficient option is usually an incandescent lamp.

- Set up the basking lamp such that the basking target gets to about 40 – 45°C when measured with a thermometer. Basking animals need strong visible light as a cue as well as infrared for heat, so visible light should also illuminate the basking spot if possible.

- If you are controlling or dimming the lamp, ensure that the thermostat's sensor is affixed to the target basking spot without being directly illuminated.

- Lamps used for basking should have a wide-flood basking area rather than a narrow intensely focused spot. This provides a more usable coverage of heat for the whole of the animal's body and avoids burns caused by small spotlights. A spotlight which heats only a small spot on a reptile's body will likely cause the animal stay under the narrow beam in the hope that the heat will eventually reach the parts of its body which are still too cool. This prolonged basking can cause burns as a consequence.

- Your animals will seek to get warm in the basking spot and will move off when warmed up. If they only bask for very short periods then the dimmer setting may be too high. If they stay for ages then the setting may be too low and they are not getting warm enough. If they stay too long and you are not providing NIR then they are simply not getting warm from the inside. They'll be hot on the outside, but too cool inside. The exact temperature values set will, of course, be determined by the species you keep.

- All three wavelength groups (UV, IR and visible light) are as important in the vivarium as they are in the wild. They work together.

- Ceramic heaters do not provide light or radiation that is of basking quality, they provide background heat only.

Penguins, reptiles and the greenhouse effect

Few people know that the longer FIR wavelengths are blocked by glass, so heat is reflected back into the enclosure – much like the greenhouse effect. In addition, there are also other materials that perform in the same way.

Recent studies with polar bears and penguins show that Keratin has similar light and heat transmission properties to glass. Keratin is the same stuff that reptile scales and scutes are made of. This makes reptiles better able to retain body heat (FIR radiation). Experiments have shown that reptiles can be at outside temperatures of 17 – 18° but reach operating body temperatures quite quickly, this is done with the help of the greenhouse effect under keratin.

Rom on YouTube

For more information and useful videos on this topic, search YouTube for Roman Muryn

Putting it into practice

There's a lot of information to process in this feature, but we hope it explains the principles behind the provision of infrared wavelengths and heating for reptiles.

We're currently working on a follow-up feature which looks at how these principles can be applied in herpetoculture, using the products that are currently available in the trade.

Watch this space.