



NATIONAL ELECTRONICS MUSEUM

ELECTROMAGNETISM WORKBOOK

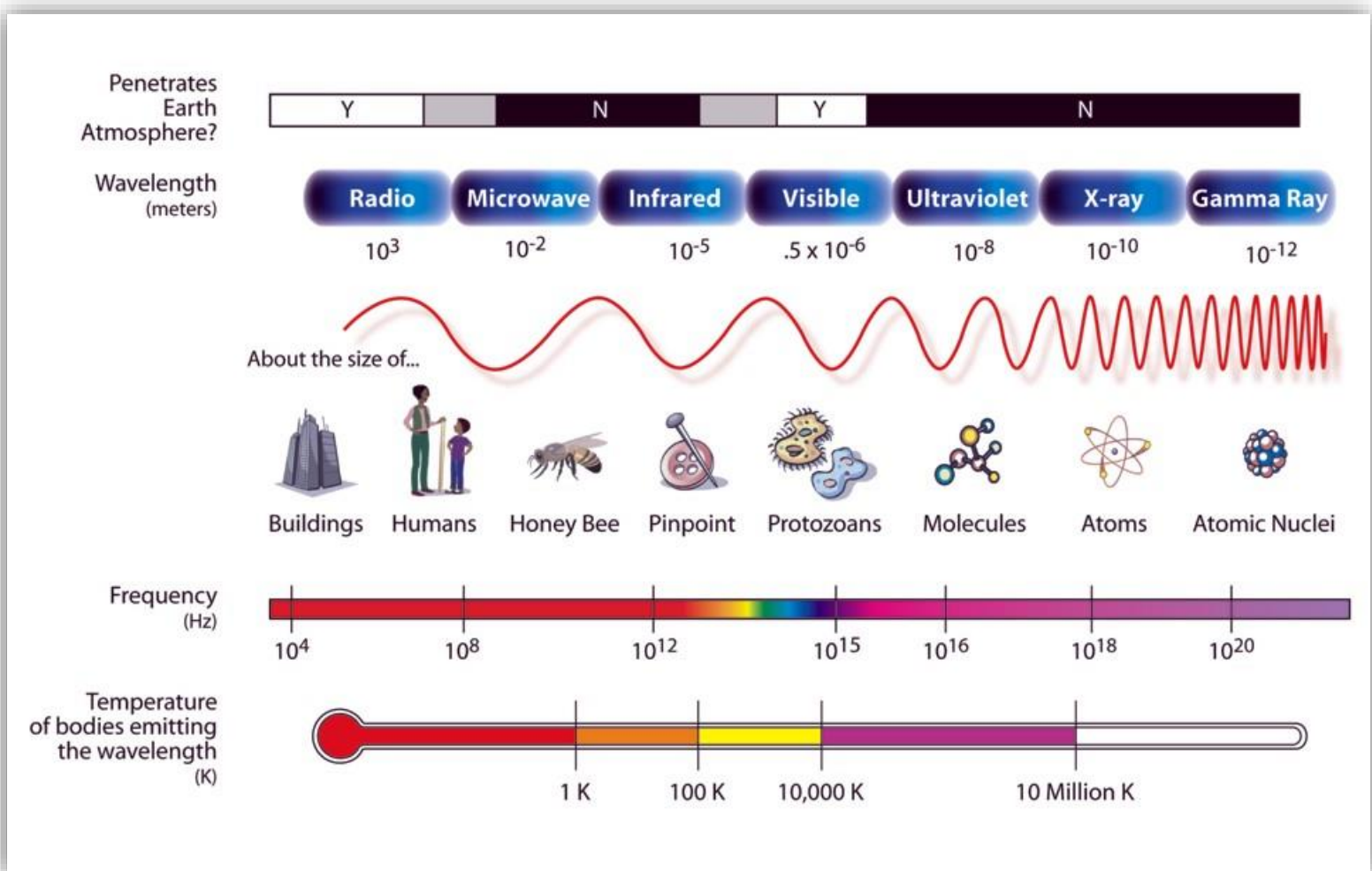
NATIONAL
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MUSEUM



The Electromagnetic Spectrum

What is the electromagnetic spectrum?

The electromagnetic spectrum is more familiar to you than you might think. The microwave you use to heat your food and the cell phones you use are part of the Electromagnetic Spectrum. The light that our eyes can see is also part of the electromagnetic spectrum. This visible part of the electromagnetic spectrum consists of the colors that we see in a rainbow - from reds and oranges, through blues and purples.



Vocabulary

Absorb - To take in or swallow up, what the color black does to light

Diffraction - Light wave spreading out as it goes through a narrow slit

Electromagnetic - A wave that contains both electric and magnetic components

Electromagnetic Spectrum - Energy transmitted in the form of electromagnetic waves (as heat waves, light waves, radio waves, X-rays)

Frequency - How often something happens, like light waves moving up and down

Gamma Ray - The shortest wavelength

Infrared - Wavelength about the size of a pinpoint, it makes our cars hot on a sunny day

Light - Electromagnetic radiation that is visible to the human eye, we need it to see

Microwave - Wavelength with range of size from people to ant, sometimes used to pop popcorn

Radio Wave - Longest wavelength, the one that allows us to watch TV

Reflect - To bend or throw back waves of light, what a mirror does

ROYGBIV - Red-Orange-Yellow-Green-Blue-Indigo-Violet, the colors of the spectrum

Spectrum - Light that makes up the colors we see, a rainbow

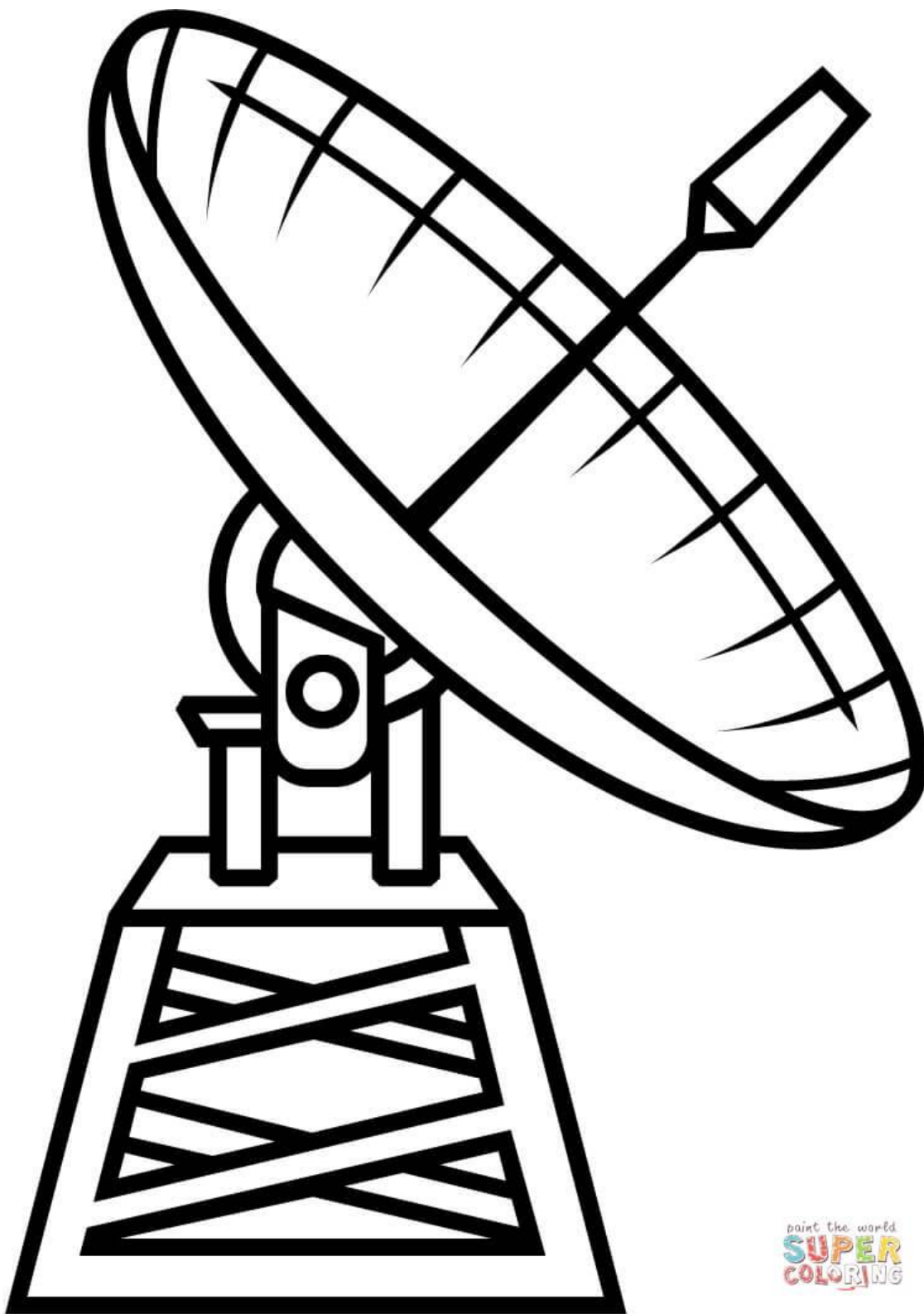
Sun - Star that provides earth with heat and light

Ultraviolet - Wavelength about the size of molecules, the reason we wear sunscreen

Visible Light - Light that we can see

X-ray - Invisible light that allows us to see bones in our bodies

THE LARGEST and LONGEST WAVES: RADIO



paint the world
SUPER
COLORING

Radio waves are as large as _____.

DID YOU KNOW? -- Radio was not just used for listening to music; many people would tune in to listen to a play for entertainment.

Ask a friend to fill in the blanks in this script for THE THREE LITTLE PIGS without showing them the script to make this classic story a one-of-a-kind play to be broadcasted on the radio!

NARRATOR

Once upon a time, there were three... 1)_____ (adjective)...pigs. The first pig built his house out of... 2)_____ (thing). The second pig built his house out of... 3)_____ (another thing different from 2). The third pig built his house out of... 4)_____ (another thing different from 3 & 4). One day a wolf went looking for his... 5)_____ (person, thing, or animal). He thought the three pigs took his... 5)_____ (same as 5).

WOLF

**Those pigs took my...
5)_____ (same as 5).**

NARRATOR

**He went to the first pig's house in...
6)_____ (name of town or city)**

PIG 1

**Welcome to...
6)_____ (same as 6).**

NARRATOR

The wolf knocked on the door and said...

WOLF

**7)_____ (adjective – describing word)...pig...
7)_____ (same as 7)...pig. Let me in!**

PIG 1

Not by the hair of my chinny, chin, chin.



NARRATOR

The wolf got mad and said...

WOLF

8) _____! (interjection – word you yell)

NARRATOR

And he huffed and puffed and blew the house down. The first pig ran to the second pig's house in... 9) _____ (Name of town or city different from 6).

FIG 2

Welcome to... 9) _____ (same as 9).

NARRATOR

The wolf knocked on the door and said...

WOLF

10) _____ (adjective) ...pig... 10) _____ (same as 10) ...pig. Let me in!

FIG 2

Not by the hair of my chinny, chin, chin.

NARRATOR

The wolf got mad and said...

WOLF

11) _____! (interjection)

NARRATOR

And he huffed and puffed and blew the house down. The pigs ran to the third pig's house in... 12) _____ (Name of town or city different from 6 and 9).



PIG 3

Welcome to... 12)_____ (same as 12).

NARRATOR

The wolf knocked on the door and said...

WOLF

13)_____ (adjective) ...pig...13)_____ (same as 13) ...pig. Let me in!

PIG 2

Not by the hair of my chinny, chin, chin.

NARRATOR

The wolf got mad and said...

WOLF

14)_____ ! (interjection)

NARRATOR

And he huffed and puffed and huffed and puffed and huffed and pulled... but the house didn't fall down. The wolf decides to go down the chimney. The pigs hurried to the fireplace, made a fire and boiled some... 15)_____ (liquid).

Narrator (CONT.)

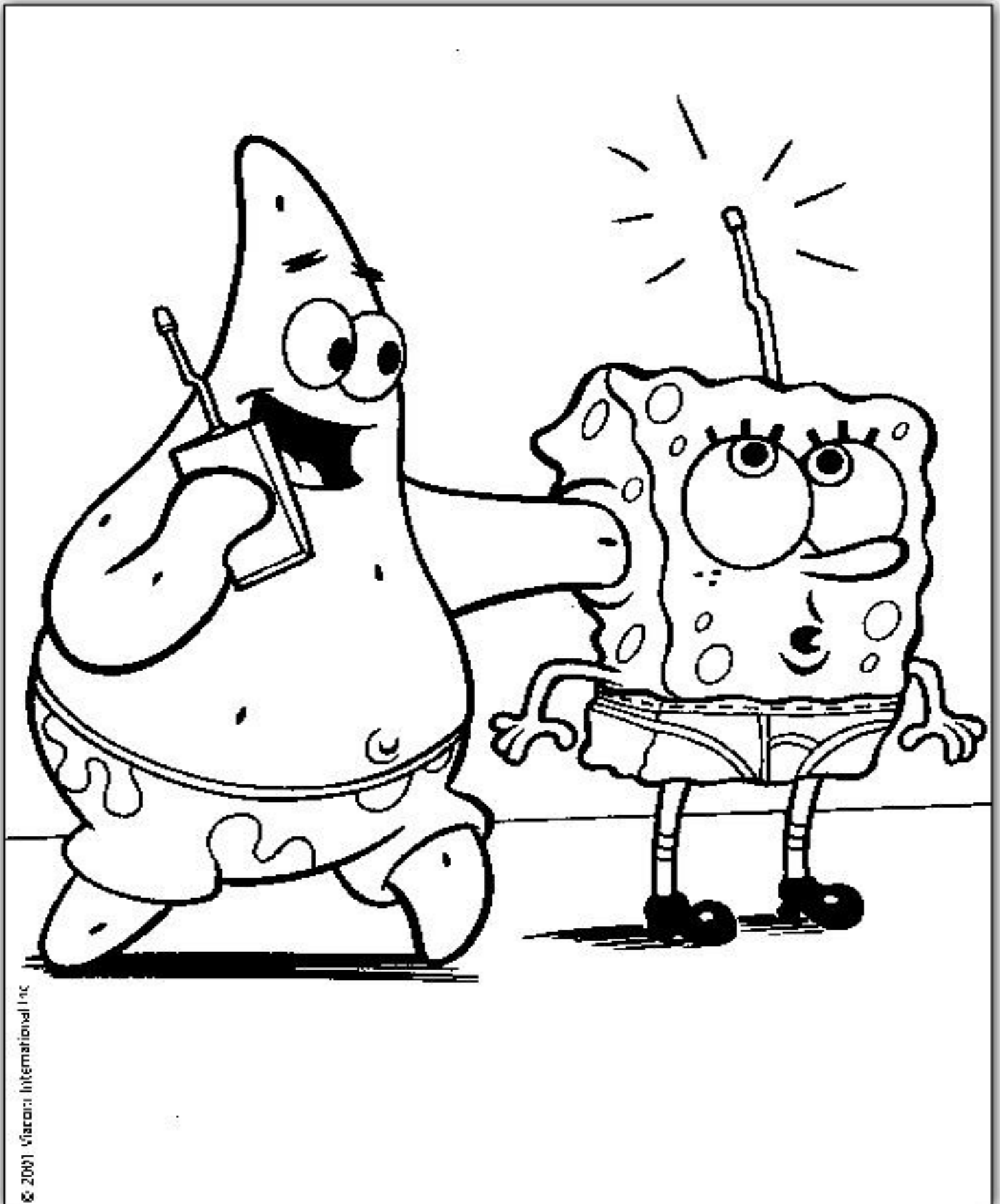
The wolf came down the chimney and fell in the boiling... 15)_____ (same as 15) ...burned his tail and ran all the way home to...16)_____ (Name of town or city different from 6, 9 and 12)

THE END!



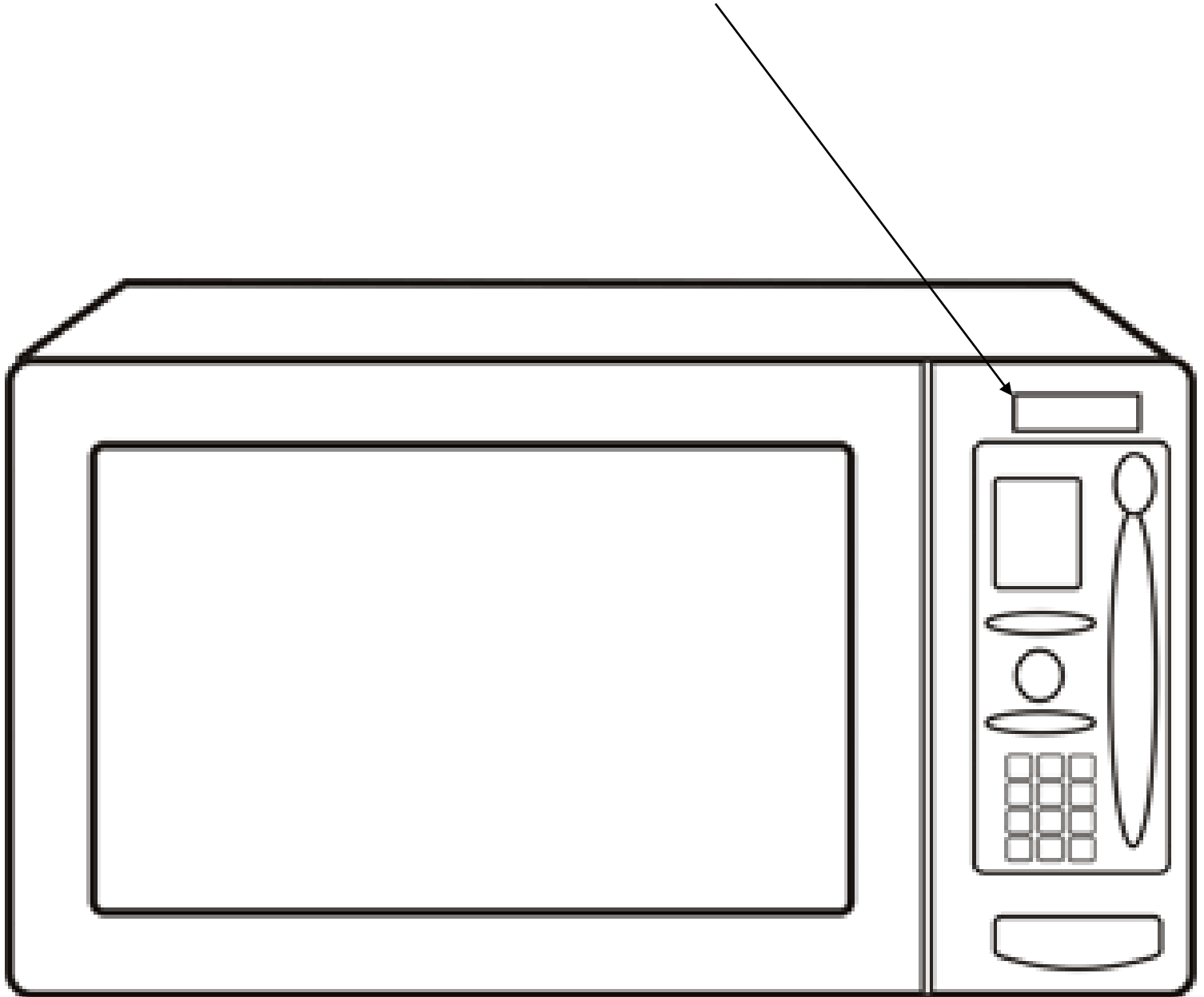
RADIO

SpongeBob and Patrick are using a form of radio in an unusual way!



NEXT UP: Microwaves

What's cooking in your microwave? Draw or color what food you are cooking in your microwave! Make sure to write how long you will be cooking it on the box.

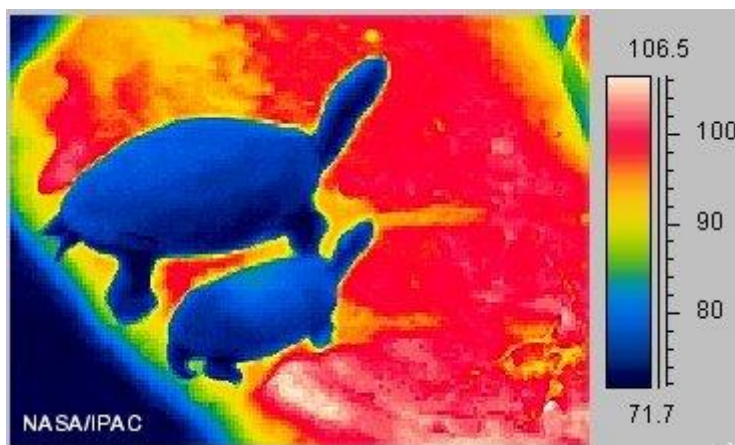


Microwaves (the actual waves, not the microwave in your house!) are about the size of _____ and/or _____.

INFRARED WAVES

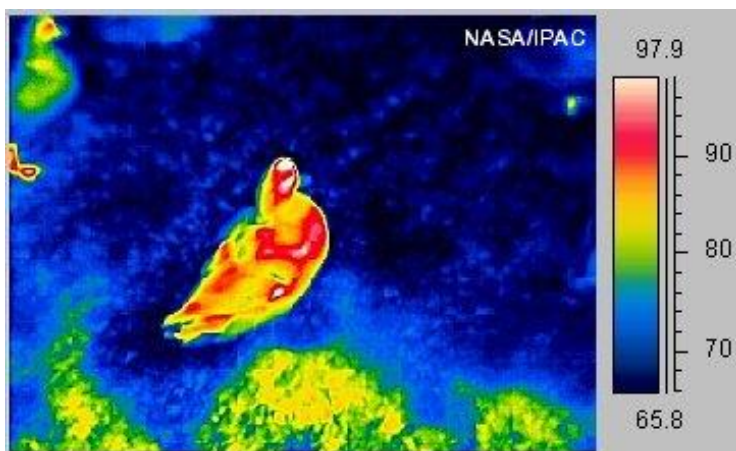
Infrared light shows us the heat radiated by the world around us. By viewing animals with a thermal infrared camera, we can actually "see" the differences between warm and cold-blooded animals. Infrared also allows us to study how well feathers, fur and blubber insulate animals.

As you tour this "Infrared Zoo", see if you can tell what animal is in the picture and if it is cold or warm blooded!



What animal is this?

Is it warm or cold blooded?



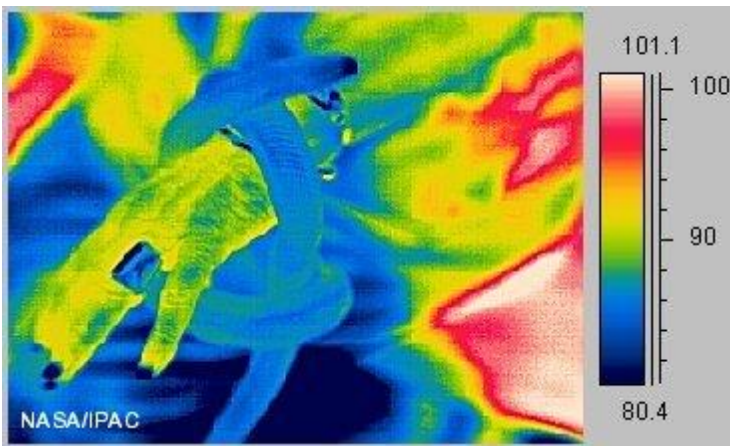
What animal is this?

Is it warm or cold blooded?



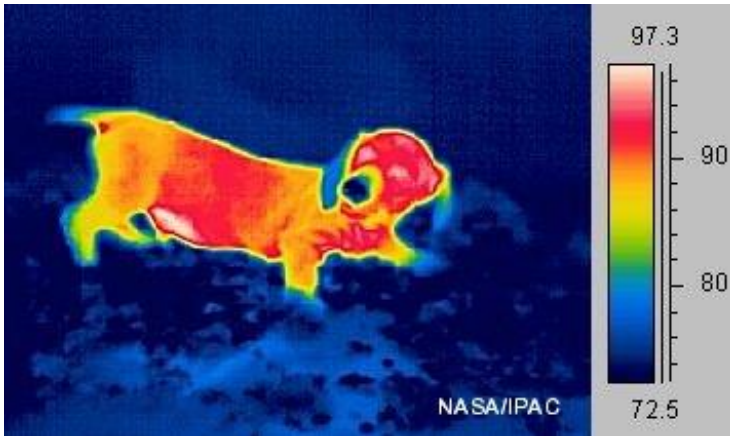
What animal is this?

Is it warm or cold blooded?



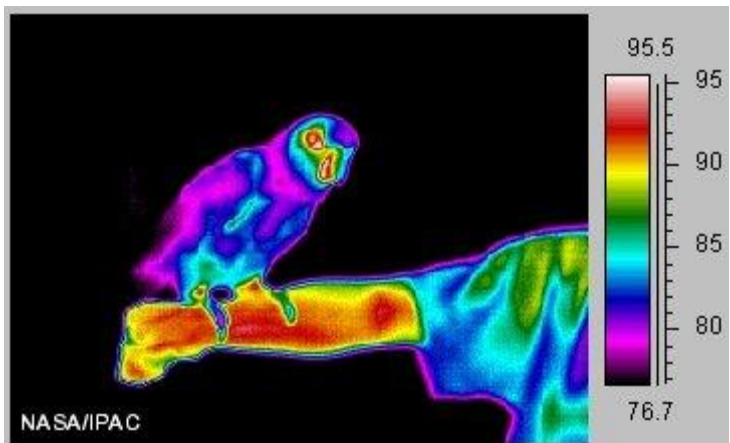
What animal is this?

Is it warm or cold blooded?



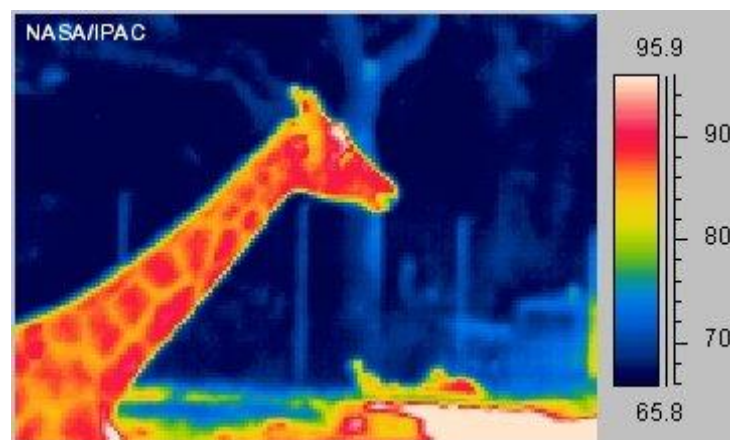
What animal is this?

Is it warm or cold blooded?



What animal is this?

Is it warm or cold blooded?



What animal is this?

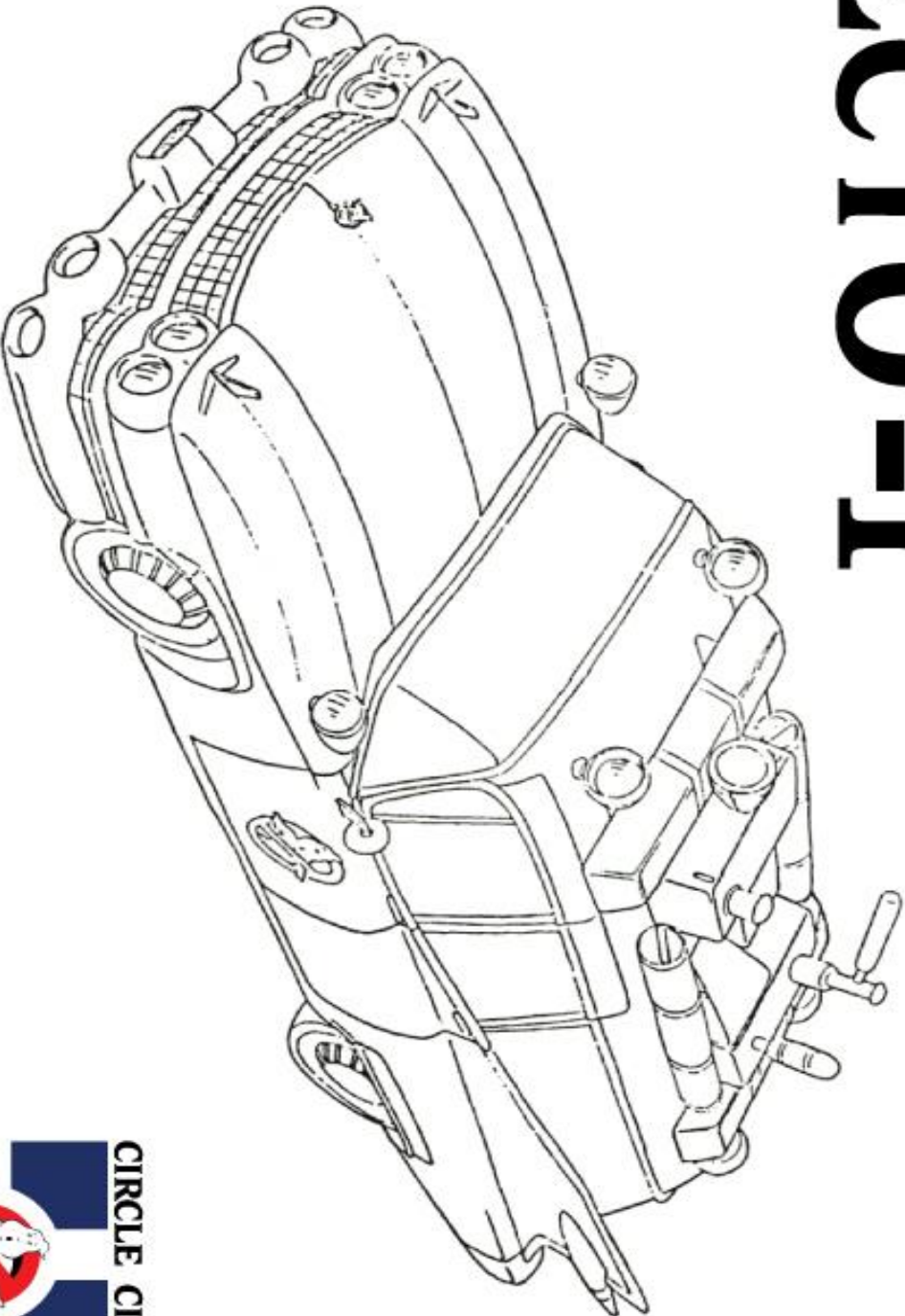
Is it warm or cold blooded?

INFRARED WAVES

The car from the movie Ghostbusters uses radar and infrared sensors to catch ghosts! Color the car!

ECTO-1

SPECIAL THANKS TO SPOOK CENTRAL FOR ALLOWING THE USE OF THIS IMAGE
WWW.THERAFFON.NET/~SPOOKCENTRAL



THE ECTO-1 IS THE STANDARD MODE OF TRANSPORTATION FOR THE GHOSTBUSTERS. THE CAR IS A 1959 CADILLAC MILLER-METEOR FUTURA DUPLEX END LOADER PAINTED WHITE AND RED SEPARATED BY A MILLER-METEOR EXCLUSIVE TRIM OPTION CALLED "FLITE-FIN". THE VEHICLE CAN EASILY HOLD ALL THE EQUIPMENT REQUIRED BY THE GHOSTBUSTERS FOR MOST JOBS. THE ROOF RACK CONTAINS VARIOUS ITEMS SUCH AS RADAR AND INFRARED SENSORS.



VISIBLE WAVES

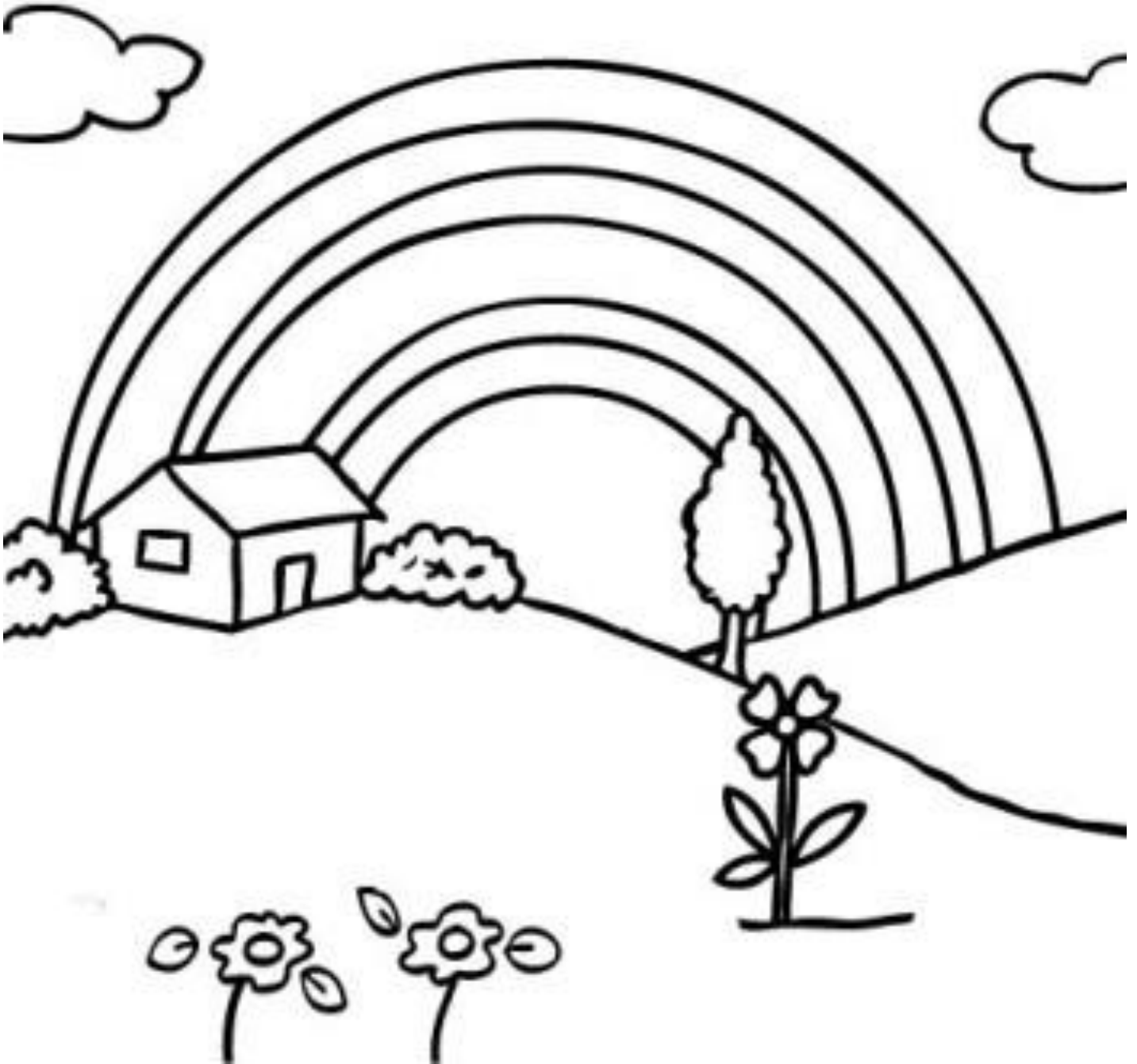
Color you own visible wave spectrum!



The waves we can see are called _____.

VISIBLE WAVES AND THE RAINBOW

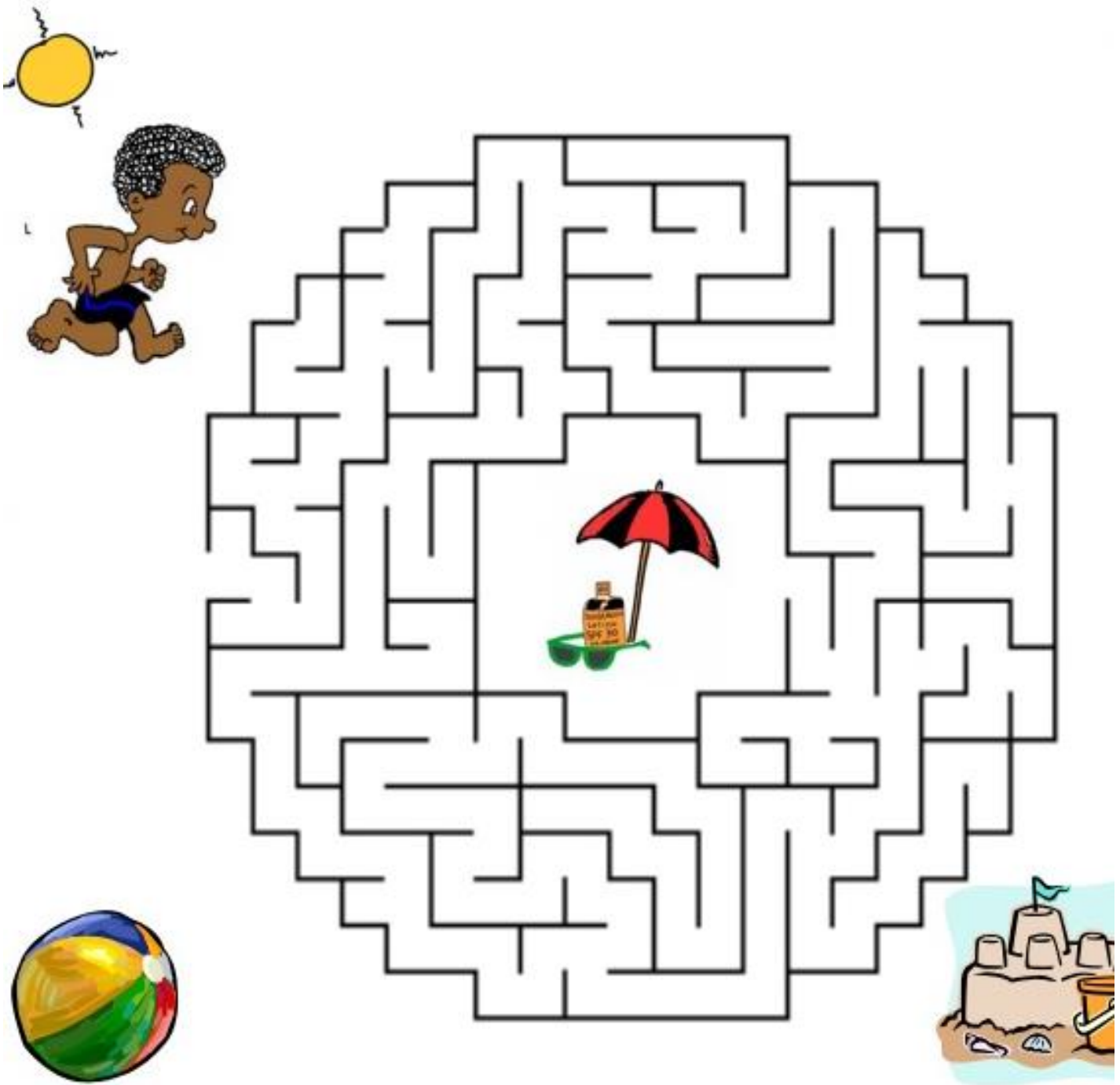
When white light shines through a prism, the white light is broken apart into the colors of the visible light spectrum. Water vapor in the atmosphere can also break apart wavelengths creating a rainbow. Color the rainbow with the colors from the visible light spectrum!



ULTRAVIOLET (UV) RAYS

You can protect your skin and eyes from damaging ultraviolet rays coming from the sun by applying sunscreen, using an umbrella, wearing sunglasses, etc.

Help Joe get through the maze to get his belongings that help him stay protected from the UV rays!



ULTRAVIOLET (UV) RAYS



There are two types of waves from the electromagnetic spectrum in this picture, can you find the sources?

X-RAYS

You get to be the x-ray technician and identify what part of the body you see from the x-ray provided!



1) _____



2) _____



3) _____



4) _____



5) _____



6) _____



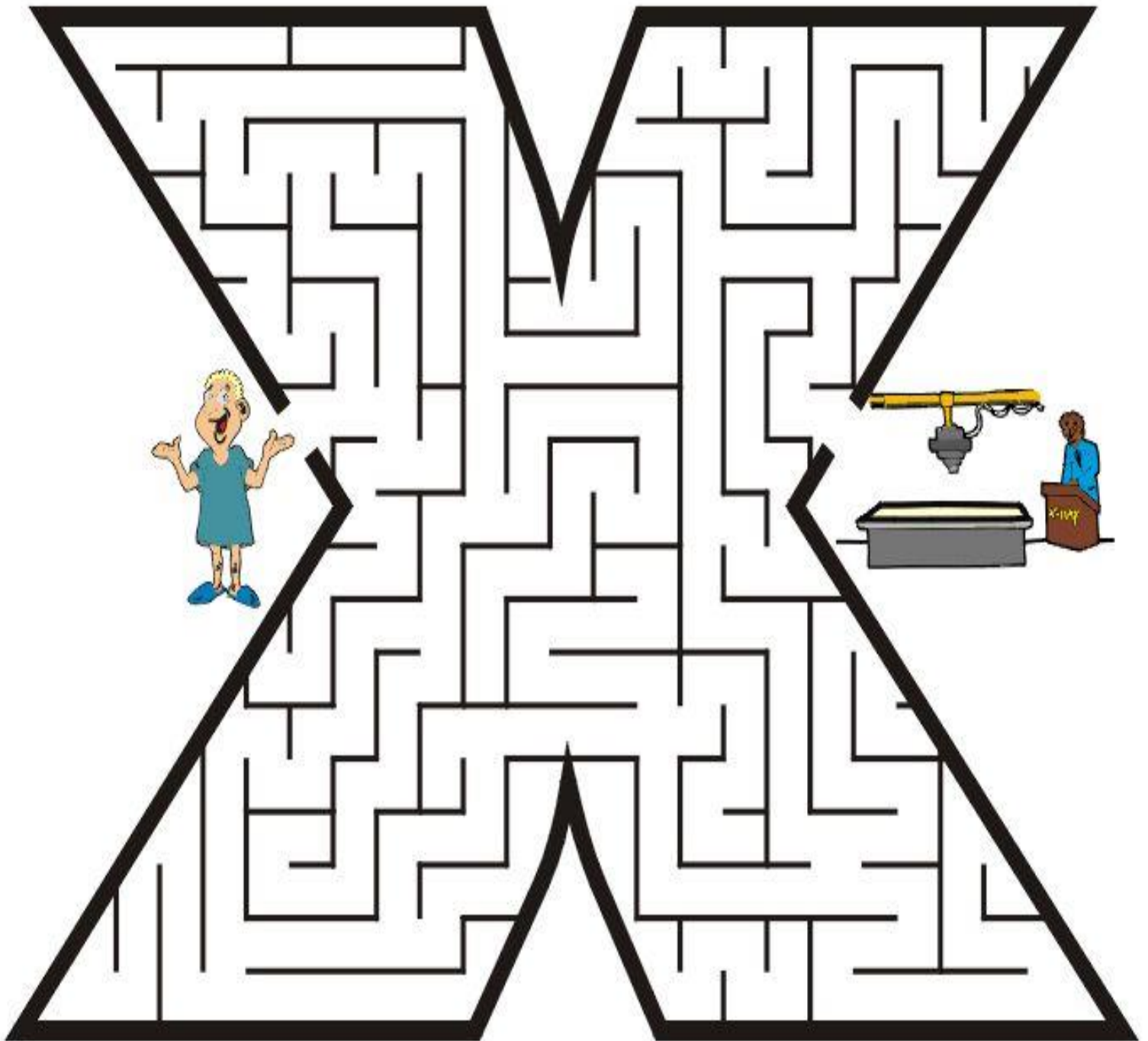
7) _____



8) _____

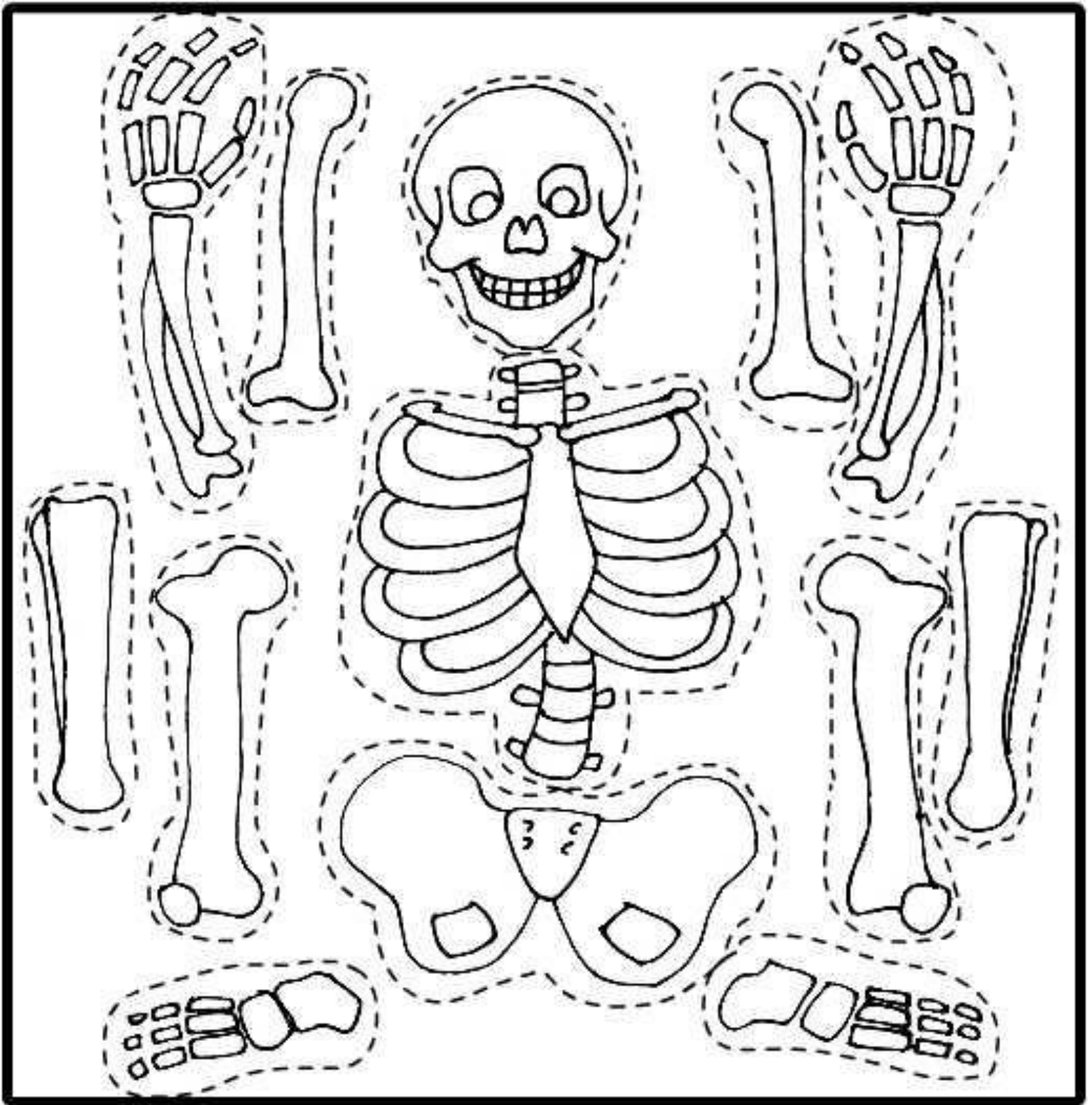
X-RAYS

Help Steve find his way to the x-ray table!



X-RAYS

If you were to take an x-ray of a human body, these are all of the bones you would find. Cut out the bones of the skeleton and glue him back together!



Gamma rays: GAMMA-GRAMS

At the high energy end of the electromagnetic spectrum we find gamma-rays. They possess a very short wavelength.

In the list below you will find terms commonly associated with the study of gamma-ray bursts. But what is a gamma-ray burst?



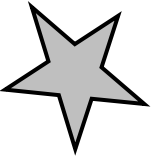
At least once a day, the sky lights up with a spectacular flash of gamma-rays coming from deep space (remember: gamma-rays are not in the visible range of the electromagnetic spectrum, so we can't see them). The brightness of this flash of gamma-rays can temporarily overwhelm all other gamma-ray sources in the Universe. The burst can last from a fraction of a second to over a thousand seconds. Currently, the exact cause of these flashes is unknown.

Beside each term you will find instructions. Follow the instructions to form a not-necessarily-scientific anagram of the designated term. You may change the order of the letters in the newly formed word. Here is an example: ray (add a d) - yard.

- 1. light (add a c)**
- 2. burst (drop a b)**
- 3. emit (add a s)**
- 4. swift (drop the w)**

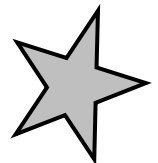
- 5. sun (add a b)**
- 5. radio (drop the i)**
- 7. wave (add an e)**
- 8. gamma (drop the g)**
- 9. wave (drop the v)**
- 10. bright (drop the g)**
- 11. emit (drop the i)**
- 12. sky (add an e)**

FUN FACTS!

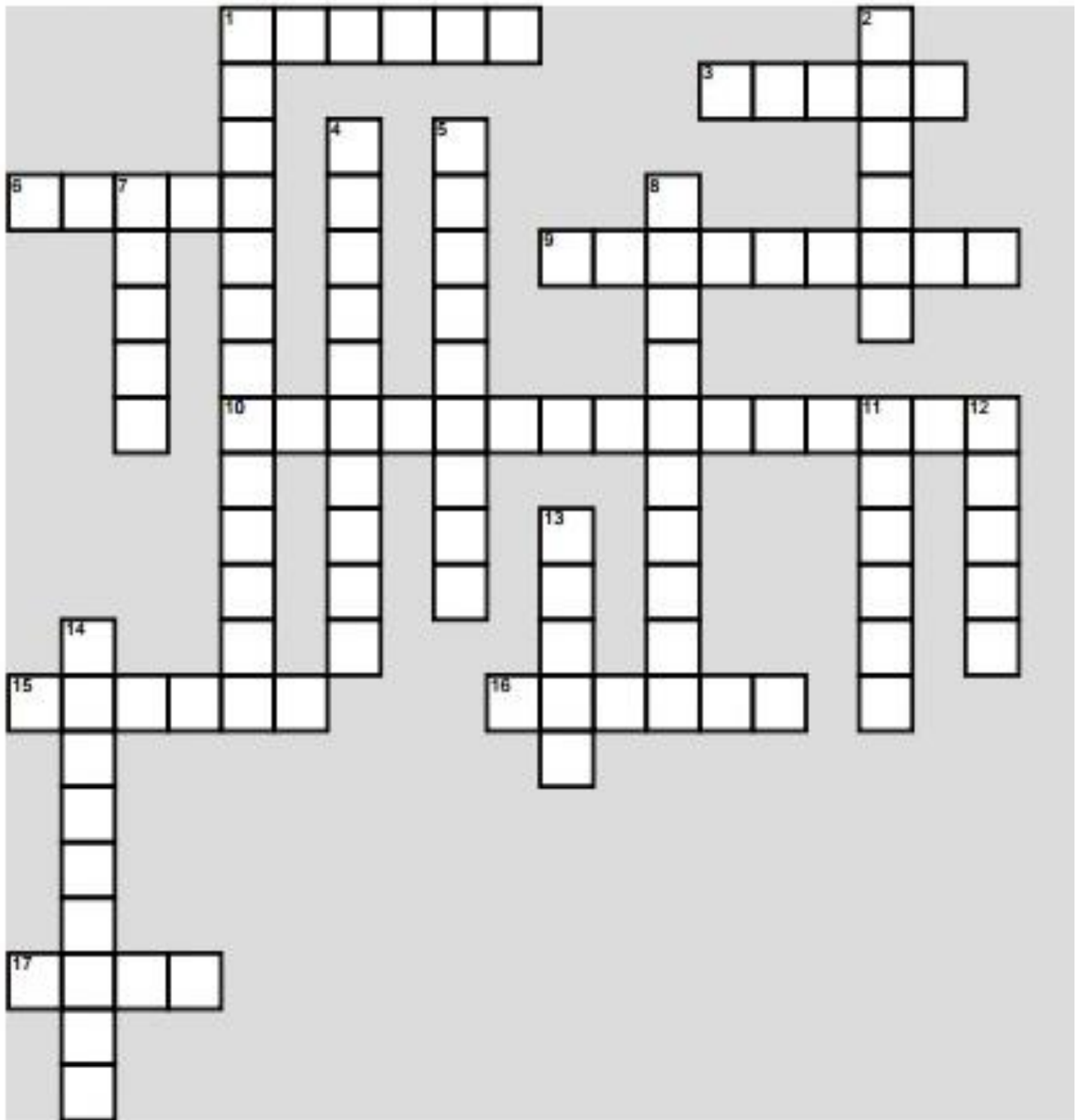


Did you know that gamma-rays can kill living cells, a fact which medicine uses to its advantage, using gamma-rays to kill cancerous cells!

Gamma-ray bursts can release more energy in 10 seconds than the Sun will emit in its entire 10 billion-year lifetime. So far, it appears that all of the bursts we have observed have come from outside the Milky Way Galaxy.



ELETROMAGNETIC SPECTRUM CROSSWORD PUZZLE #1



Clues on the next page!

Across

- 1. Bundle of light energy**
- 3. In the eyes cause color vision**
- 6. The speed of this energy form is 3.0×10^8**
- 9. Measured in HZ**
- 10. Wave type that does not require a medium to travel through**
- 15. His constant is used to calculate the amount of energy in a photon**
- 16. Of the visible light the color with the most energy**
- 17. In the eye is sensitive to white light**

Down

- 1. The effect that causes metals to release electron when hit by a frequency of light**
- 2. Part of eye that is sensitive to light**
- 4. The distance from crest to another crest of a wave**
- 5. The height of a wave**
- 7. Of the electromagnetic spectrum the one with the highest energy**
- 8. Wave type that requires a medium to travel through**
- 11. The low point on a wave**
- 12. The peak of a wave**
- 13. The wavelength of the electromagnetic spectrum with the longest wavelength**
- 14. Are ejected when metal are hit by specific frequency of light**

ELECTROMAGNETIC SPECTRUM WORD SEARCH #1

E V N M X O E Y W F N K N B M D N I H M K D R H K
F H C K J X A V I R X Q N I F B S U G T O R Q S J
C C J W L R Q Z A H Q D C T I Y C N E U Q E R F Q
H C D V A V L S N W Q R O B U K Z W L I R F N O D
B C W M J E V S U C O T C I R P Y Y O W S L B F I
I U M P M B B R T W A I J R N G Q D K N Q E F G W
X A R N N X T W A Q K H D P O P A A B X M C O K E
G V E U R Q Z V N B C A L A C Y F X D W U T A S K
V I S I B L E L I G H T H I R H G G S Y R D D S N
T H G I L B F J C W N N T Q L K N B O B T I A O K
O O V D A L O X B O U E U A U L U G I K C F M Z A
F V Z E R D I P H Y N E I L F W S O B V E F W R Z
Q X O P Y E F U K G H M O U T K R Y H M P R Z H N
E B W O U A G Q A M T J G Y O R M N L L S A E Y I
S S K O E A R M N H X H T A C F A Z R H J C M I W
Y X X U M Q O X C L C H T X X R H V I P U T P V J
E W E Z K R A G I C E H V V J T P N I Q C I H B E
G U B A T T Q X I N F R A R E D Q Q Z O F O C J R
I E C C W D B X I D X U Q X B I B K E E L N F D T
H L E Z A A T X N S P P W Q F V F Y Q T A E A K J
L L A R B M G D X Q P Y H E F O Y U U T Z G T Z B
E Y A S Y K I P F U Q P T C L L Y L R F M O L R V
N W O Q J S D O R Z A F A C J B C P E F B L O K U
O R G L N B F Q I A L T K K J Z H K V M G Q E N C
B C U Y J Z K O I X M C S J V E G L M T A U W R J

ULTRAVIOLET

ROYGBIV

REFLECT

MICROWAVE

FREQUENCY

XRAY

SPECTRUM

DIFFRACTION

SUN

ELECTROMAGNETIC

GAMMA RAY

VISIBLE LIGHT

ABSORB

INFRARED

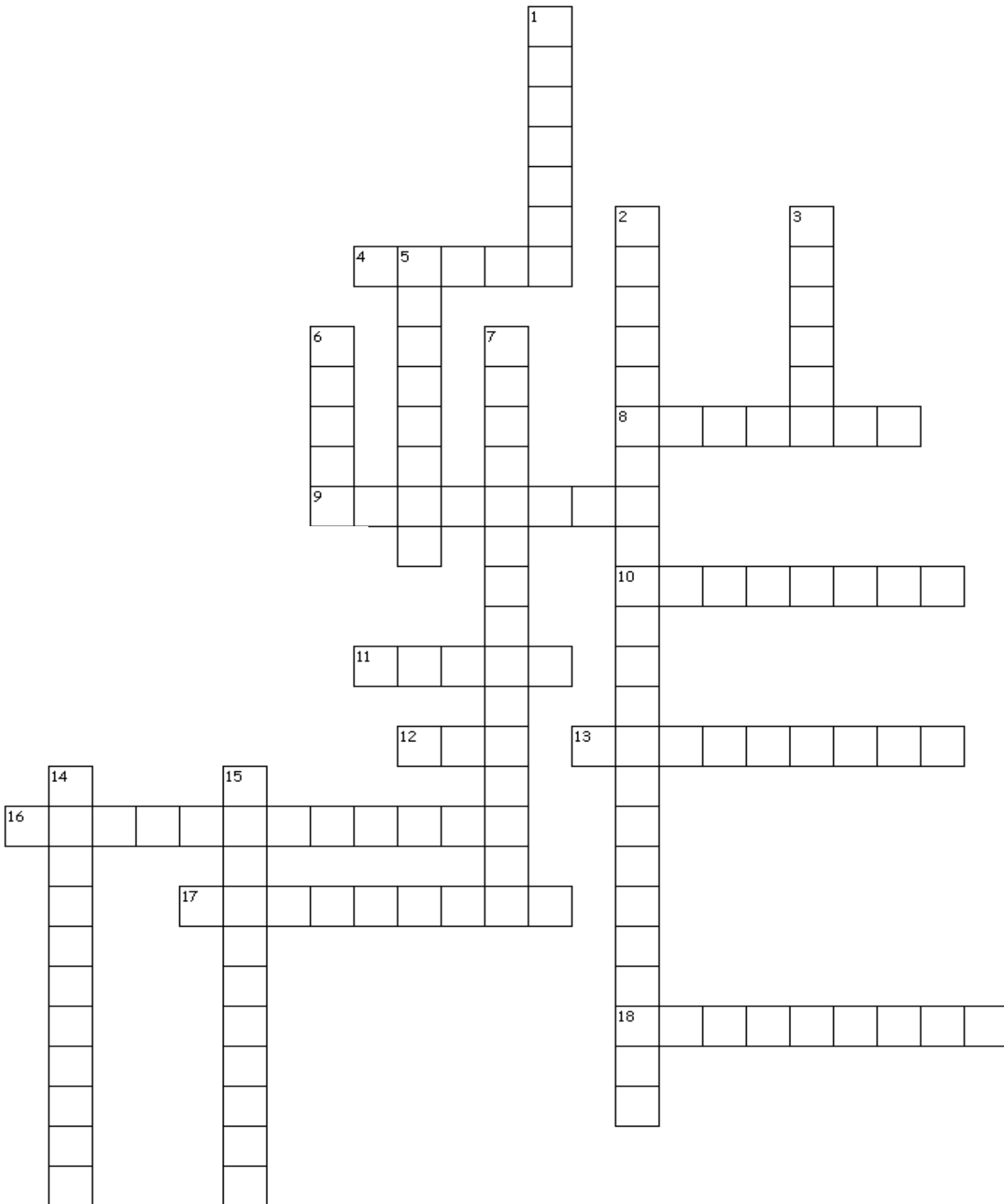
RADIOWAVE

ELECTROMAGNETIC SPECTRUM WORD SEARCH #2

N U H G H B W O L L E Y P Q W
R E I I I F G U C Y K D P D A
X N E P A O I A Z E A E T U N
Z S G R Y C N E U Q E R F D I
I K H T G N E L E V A W X G D
A K P A X C B G M N M I C R O
H Z M X K D Y X S A P Y F Q S
I M T E L O I V P H L Y J Z J
A M N T M S E O E Q I I N F X
V U S I F R E X E N T N G S V
E B K S S A S C D D U S F H K
C G D E D D Y I M G D L T R T
Z H D A C I G U P B E J T L A
E G N A R O K F S V U R T R M
D E V Y Y M B D T K G D O J A

Amplitude	Blue	Frequency	Gamma	Green
Indigo	Infra	Light	Micro	Orange
Radio	Red	Speed	Transverse	Ultra
Violet	Wavelength	X-Ray	Yellow	

ELECTROMAGNETIC SPECTRUM CROSSWORD PUZZLE #2



Clues on next page! Use the vocabulary sheet if you need help!

Across

- 4. Electromagnetic radiation that is visible to the human eye, we need it to see**
- 8. Red-Orange-Yellow-Green-Blue-Indigo-Violet, the colors of the spectrum**
- 9. Light that makes up the colors we see, a rainbow**
- 10. The shortest wavelength**
- 11. Invisible light that allows us to see bones in our bodies**
- 12. Star that provides earth with heat and light**
- 13. Wavelength with range of size from people to ant, sometimes used to pop popcorn**
- 16. Light that we can see**
- 17. How often something happens, like light waves moving up and down**
- 18. Longest wavelength, the one that allows us to watch TV**

Down

- 1. To bend or throw back waves of light, what a mirror does**
- 2. Energy transmitted in the form of electromagnetic waves (as heat waves, light waves, radio**
- 3. To take in or swallow up, what the color black does to light**
- 5. Wavelength about the size of a pinpoint, it makes our cars hot on a sunny day**
- 6. The frequency of _____ is measured in meters.**
- 7. A wave that contains both electric and magnetic components**
- 14. Light wave spreading out as it goes through a narrow slit**
- 15. Wavelength about the size of molecules, the reason we wear sunscreen**

The Electromagnetic Spectrum: Uses and Effects

Complete the table below by matching the types of radiation with its effect on living tissue and its use.

Types of radiation	Effects on living tissue	Used for...
Gamma	High doses can kill living cells Lower doses can cause cancer in cells	Treating tumors Sterilizing hospital equipment
X-Ray		
UV		Fluorescent tubes Security marking
Visible		
Infrared		
Microwave	Heating of water in tissues can cause burning	Satellite communication Cooking
Radio		

Cut out the blocks on the next page and glue them where they belong.

Probably none

**Communication (hint: your
play!)**

RADAR

**Creating images of the
inside of the body**

**Causes burning of tissues
(hint: sun burn!)**

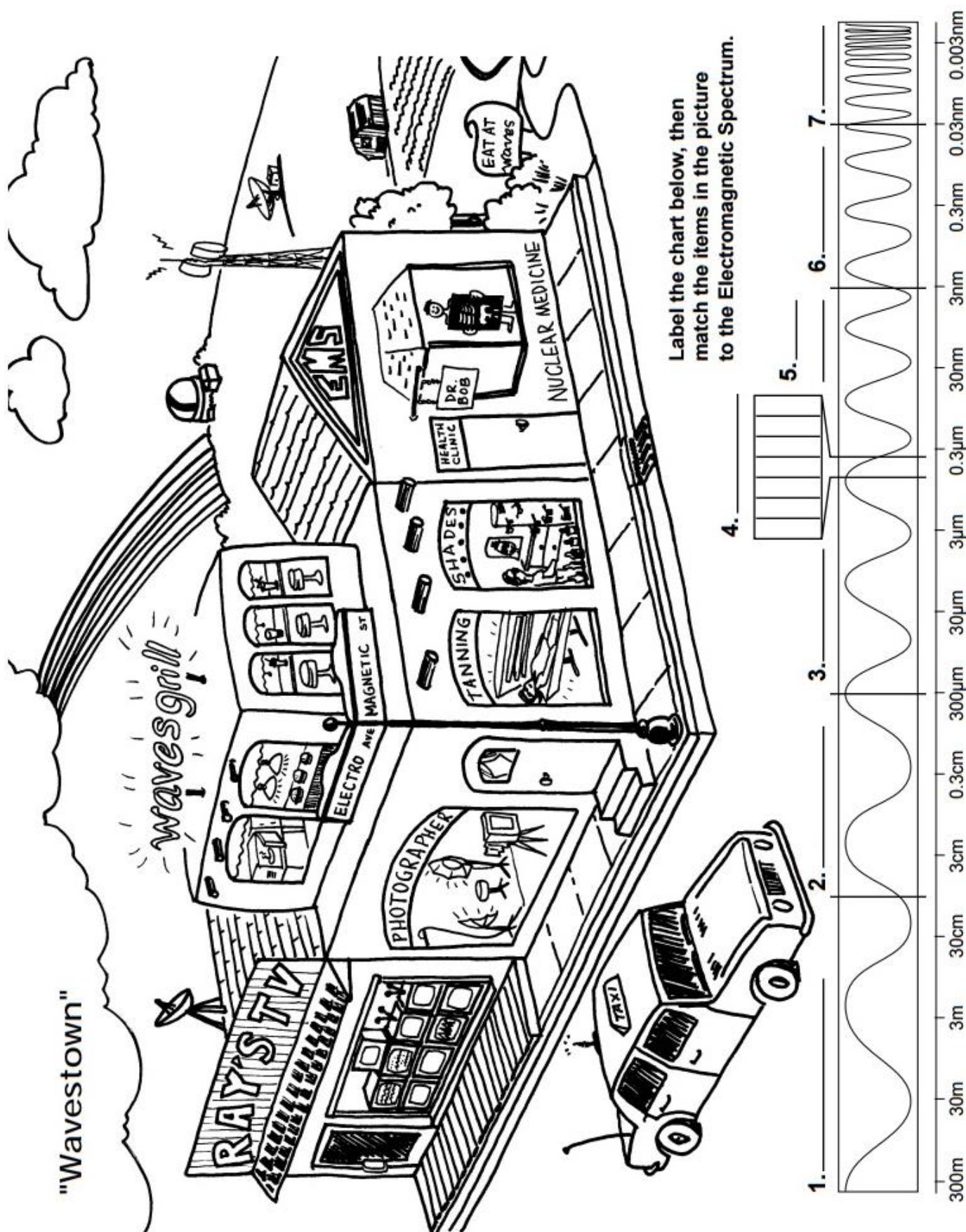
**Seeing Optical fibers and
communications**

**High doses can kill living
cells. Lower doses can
cause cancer.**

**Remote controls and
thermal imaging (hint: zoo
animals!)**

**Activates sensitive cells
in the retina (eye)**

**High doses can kill living
cells. Lower doses can
cause cancer.**



Wavestown Answer Key

Radio Waves

Ray's TV - TV reception uses radio waves

Satellite Dish at Ray's TV - receives movies via radio waves from a satellite

Taxi - Car radio receives radio wave signals

Taxi - Driver receives instructions on a CB radio which uses radio waves

Radio Tower - broadcast's radio signals

Large Satellite dish in field - receives radio waves from distant stars

Microwaves

Microwave in Waves Grill - uses microwaves to cook food

Disk-like antennas on tower - send microwave communications

Infrared

Heat lamps above food in Waves Grill - use infrared waves to keep food hot

Ray's TV - Remote controls use infrared waves to communicate with the TV

Trees, bushes, grass, and farm - vegetation reflects short infrared waves

Observatory - astronomers study thermal infrared (long infrared waves) from stars

Visible Light

Rainbow - water droplets cause white light to break apart into the colors of the rainbow

Photographer's studio - portrait photographers use film sensitive to visible light

Observatory - astronomers look at visible light from planets and stars

Ultraviolet

Tanning Salon - use ultraviolet waves to tan our skin

sunglasses store - sunglasses protect our eyes from the ultraviolet waves

Suntan lotion - protects our skin from ultraviolet waves

Observatory - astronomers see some ultraviolet radiation from planets and stars

X-rays

Dr.Bob's Health Clinic - uses x-rays to study our bones

High energy x-rays are also used to treat cancer

Gamma Rays

Dr.Bob's Health Clinic - gamma radiation is used to kill sick cells through nuclear medicine

Gamma radiation is given off by nuclear explosions that occur within stars, like our sun.

Visible Light Color-by-Number

“Visible light” corresponds to a wavelength range of 400 - 700 nanometers (nm) and a color range of violet through red. The visible colors from shortest to longest wavelength are: violet, blue, green, yellow, orange, and red. The white light is a mixture of the colors of the visible spectrum. Black is a total absence of light.

Violet Light

The visible violet light has a wavelength of about 400 nm. Within the visible wavelength spectrum, violet and blue wavelengths are scattered more efficiently than other wavelengths. The sky looks blue, not violet, because our eyes are more sensitive to blue light (the sun also emits more energy as blue light than as violet).

Indigo Light

The visible indigo light has a wavelength of about 445 nm.

Blue Light

The visible blue light has a wavelength of about 475 nm. Because the blue wavelengths are shorter in the visible spectrum, they are scattered more efficiently by the molecules in the atmosphere. This causes the sky to appear blue during the main part of the day, when blue light is scattered into your eye no matter which direction you look.

Green Light

The visible green light has a wavelength of about 510 nm. Grass, for example, appears green because all of the colors in the visible part of the spectrum are absorbed into the leaves of the grass except green. Green is reflected, therefore grass appears green.

Yellow Light

The visible yellow light has a wavelength of about 570 nm.

Orange Light

The visible orange light has a wavelength of about 590 nm. Low-pressure sodium lamps, like those used in some parking lots, emit an orange-ish (wavelength 589 nm) light.

Red Light

The visible red light has a wavelength of about 650 nm. At sunrise and sunset, the light you see has traveled a longer distance through the atmosphere. A large amount of blue and violet light has been removed as a result of scattering and the longwave colors, such as red and orange, are more readily seen.

Purple = 400 nm

Indigo = 445 nm

Blue = 475 nm

Green = 510 nm

Yellow = 570 nm

Orange = 590 nm

Red = 650

Color each section by using the chart on the previous page and matching the correct the correct wavelength to the correct color. For example, a shape with 650 (nm) would be colored red!

