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PALEONTOLOGY 7: MESOZOIC

VOLUME 9, ISSUE 7, MARCH 2020

THIS MONTH

- DNA to Proteins
 - Transcription page 2
 - Translation page 5
 - DNARNA to Proteins Tutorial page 8
- Dioramas of the Mesozoic Era page 11
- Mesozoic Era Timeline page 15

POWER WORDS

- **archosaur**: a reptile of a large group that includes the dinosaurs and pterosaurs; is represented today only by the crocodilians and birds
- **MYA**: million years ago
- **Permo-Triassic Extinction**: the Permian Extinction AKA The Great Dying
- **synapsid**: mammal-like reptile

CAREER CONNECTION

- Evaluating your project page 24

TERRIFYING ENORMOUS BEASTS!

Most people think of dinosaurs when they think of paleontology. You know different now, since we have focused on so many other aspects, including fossils found from the Paleozoic. There is no question, though, that dinosaurs are the big show!

The Mesozoic is the Age of the Dinosaur. They are not the only **archosaurs**, though. There were also flying and swimming reptiles. All three groups had terrifying and massive beasts.

The **Permo-Triassic Extinction Event** (also called the Great Dying) saw an enormous loss of mammal-like reptiles. Some did make it through that event (fortunately for us), but they eventually disappeared about 100 **MYA**. The first appearance of true mammals is from 160 **MYA**. Remember, the **synapsids** and mammals both shared an ancestor from much earlier, just like your third cousins and you share great-great grandparents.



One of the first placental mammals from 160 **MYA** was very shrew-like

The Mesozoic Period lasted 186 million years, from 252 to 66 **MYA**. Recall the work we did on big numbers in the first issue in this series (53.Paleontology 1 starting on page 2 <https://tra.extension.colostate.edu/stem-k12/stem-resources/>). If you convert seconds to year, 186 million seconds is almost 6 years! Wow!

This month completes the background information needed to understand how mutations in the DNA impact organisms, and eventually lead to speciation. We will finally get to mutations next month! The rest of this issue is devoted to all the life that lived during the Mesozoic except for dinosaurs. Next issue: **DINOSAURS!**



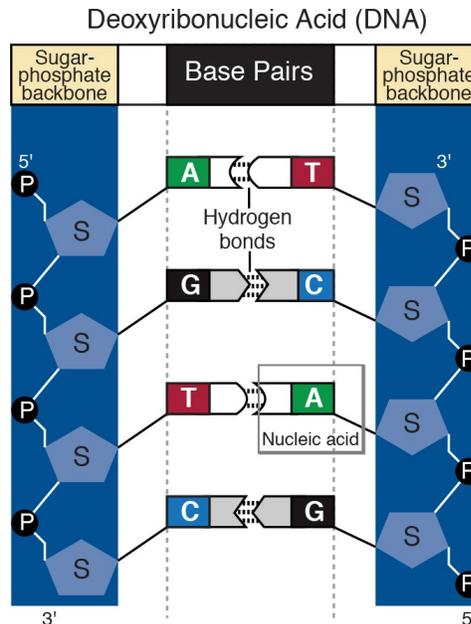
SCIENCE, TECHNOLOGY,
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4-H PROGRAMS ARE AVAILABLE TO ALL WITHOUT DISCRIMINATION

DNA **transcribes** to RNA. RNA **translates** to proteins. Proteins provide function and structure to cells. Get ready for the **translation** to proteins. With this information, you will have the background necessary to understand **mutation** in the DNA, and how that impacts the organism.

Directions:

- Oh no! You need to make the marshmallow / licorice DNA again!
- Every cell in your body (except mature red blood cells) have DNA (the immature red blood cells do have DNA). The DNA is identical in every single cell in your body! DNA is has two **strands**. Each **strand** has a “sugar phosphate” backbone (licorice twist). This structure makes DNA very stable. Located on the inside are 4 molecules that act like the letters of the genetic alphabet) adenine (A), thymine (T), guanine (G), and cytosine (C).



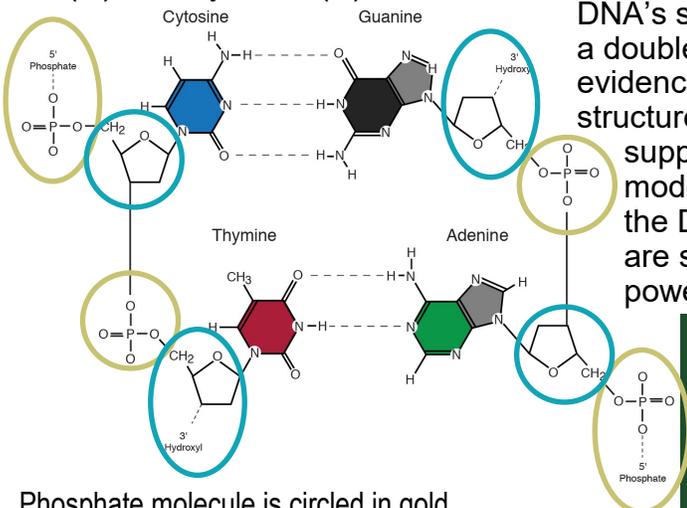
- Adenine has two hydrogen bonds to thymine on the opposite DNA **strand**. guanine has three hydrogen bonds with cytosine on the opposite DNA **strand**. When they are hydrogen bonded, are called **nucleobase** pairs (or base pairs; AT and GC). Hydrogen bonds hold the base pairs together like weak magnets.

This shape is called a helix. DNA’s structure is therefore a double **strand** helix. All the evidence we have for the structure of DNA is robustly supported. With this model, you can visualize the DNA molecules that are so small that the most powerful microscopes

POWER WORDS

- **mutation:** DNA gene is damaged or changed in such a way as to alter the genetic message carried by that gene
- **strand:** a single thin length of something such as thread, fiber, wire, or DNA
- **translation:** RNA is “read” by a ribosome to know which amino acid to attach next to the growing protein **strand**
- **transcription:** DNA **strand** is read and the complimentary **nucleobase** is paired to make messenger RNA—note that adenine pairs with uracil instead of thymine in RNA

can not take clear images. Models help us to understand the natural world that is either too small, too far away, or too big to imagine. You can see the base pairing of adenine to thymine (Orange marshmallows pairs with Yellow marshmallows) and guanine to cytosine (Green pairs with Pink).



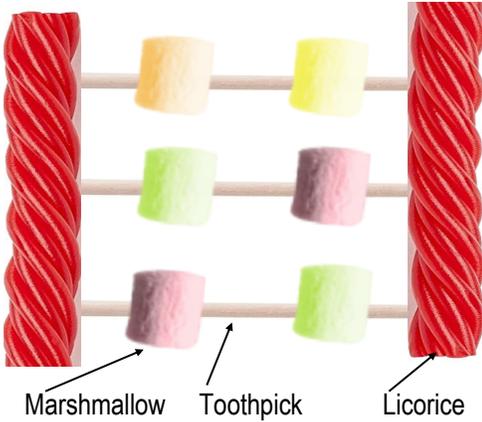
Phosphate molecule is circled in gold, and sugar molecule is circled in blue. They form the backbone. Each **nucleobase** pair (A=T and G≡C) bonds with the base on the other **strand**.

MATERIALS

- colored mini-marshmallows (pink, green, yellow, orange and white)
- licorice twists
- toothpicks
- sharp scissors
- print page 7
- labels (or small strip of paper and tape)
- marker or pencil

Directions:

- Space the 12 toothpicks as evenly as possible, and push them into the licorice twist on one side.



- The sequence on one **strand** of DNA:

A T A G G C C A A G A T

- Using the marshmallow color code (in green box below right), push a marshmallow of the right color $\frac{2}{3}$ on the toothpick. Verify colors:

O Y O G G P P O O G O Y

- Add the **complementary nucleobase** to the toothpick, leaving a gap between the two marshmallows.

Remember

- A-T (pink-yellow),
- G-C (green-orange).

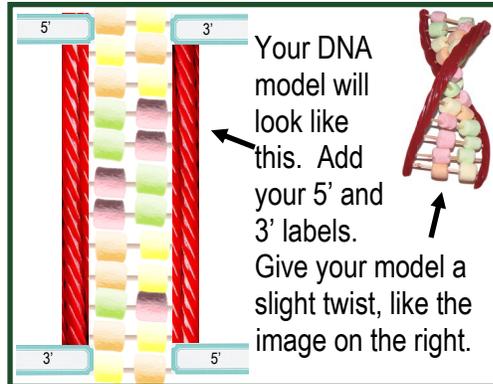
- Check your second **strand**:

T A T C C G G T T C T A

Verify colors:

Y O Y P P G G Y Y P Y O

- Push your second licorice twist onto the open end of the toothpicks. Take care that the toothpicks do not poke you! The image in the center column, top left, will match your licorice/marshmallow DNA.
- Label the 5' and 3' end of DNA (read 5' as "five prime" and 3' as "three prime"). The first sequence you built, use the ATA (OYO) as the 5' end, and the GAT (GOY) as



- the 3' end. Complementary DNA's 3' end is TAT (YOY) and the 5' is CTA (PYO). Use sticky labels (or a paper strip and a piece of tape) as depicted in the image above.
- Twist the two ends to form a double **strand** helix DNA! (See image above right.)

Transcription:

- In real DNA, the hydrogen bonds act like weak magnets. They are pulled apart to read the DNA, and snap back together. The toothpicks between the marshmallow **base pairs** can not unzip. You need to cut your model with scissors.
- Cut the toothpicks between the marshmallow **base pairs** (see image on the next page)

POWER WORDS

- base pair:** a pair of complementary bases in a double-**strand** nucleic acid molecule
- complementary:** related by the rules of base pairing A-T, A-U, and G-C
- helix:** spiral chain
- junk DNA:** genomic DNA that does not encode proteins, and whose function, if it has one, is not well understood
- nucleobase:** the building blocks of DNA and RNA: adenine, thymine, guanine, cytosine, and uracil

- with a sharp pair of scissors to model how DNA is separated by the **RNA polymerase**.
- RNA polymerase** reads **genes** to make

DNA—Marshmallow Color Code

Adenine (A) = orange (O) pairs with Thymine (T) = yellow (Y) in DNA
 Thymine (T) = yellow (Y) pairs with Adenine (A) = orange (O) in DNA
 Guanine (G) = green (G) pairs with Cytosine (C) = pink (P) in DNA & RNA
 Cytosine (C) = pink (P) pairs with Guanine (G) = green (G) in DNA & RNA

FASCINATING FACTS

- You have over three billion **nucleobase pairs**!
- Proteins range in size from about 50 to 2,000 **amino acids** long. That means, 150 to 6,000 **nucleobases** are needed to make that protein.
- At least 75% of human DNA is **junk DNA**! **Junk DNA** is the term given to DNA that does not directly code for proteins. It may be necessary for the proper function of DNA, or genes that no longer code for proteins.



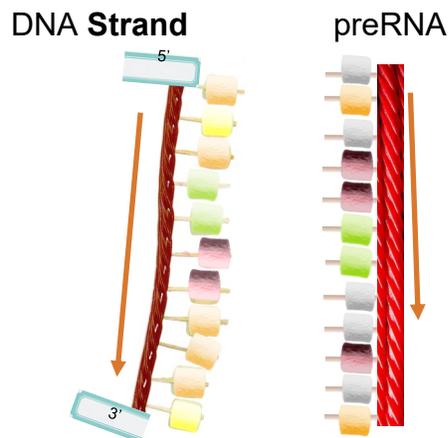
messenger RNA (mRNA). This process is called **transcription**. You will make **mRNA** from only one **strand** of your marshmallow/licorice DNA. **Genes** can be on either **strand** of DNA, but the **gene** will only be read on one **strand**. The **complementary strand** can have junk DNA, or even have a different **gene** that will code for a completely different protein.

- **RNA** is single **strand** and has the **complementary nucleobases** to the DNA **strand** being read. One major exception is the **complementary nucleobase** to adenine (A) on RNA is uracil (U), not thymine. Use a white mini-marshmallow to represent Uracil (U) instead of using the yellow marshmallow for thymine.
- The DNA is read by the **RNA polymerase** from the 5' end to the 3' end. If you use the

DNA on the left (black arrow), start at the top, and the complementary tRNA would be added one at a time from the DNA's 5' to the 3' end (direction of the orange arrow).

Directions:

- RNA also has a sugar-phosphate backbone. Space the 12 toothpicks evenly along a licorice twist and push them into the twist.
- To form your **preRNA strand**, line up the cut DNA **strand** with the licorice twist and toothpicks (image below). The exposed DNA **nucleobases** are



POWER WORDS

- **chromosome**: a threadlike structure of nucleic acids found in the nucleus of most living cells, carrying genetic information
- **gene**: a distinct sequence of nucleobases forming part of a **chromosome**, the order of which determines a protein's amino acid sequence
- **macromolecule**: any molecule containing a very large number of atoms
- **preRNA**: messenger RNA while it is being transcribed from DNA, and before final editing takes place
- **RNA polymerase**: the macromolecule that is responsible for copying a DNA sequence into RNA during translation

unzipped and used to make a **complementary** copy. This copy will be messenger RNA (mRNA).

RNA—Marshmallow Color Code

Adenine (A) = orange (O) pairs with Uracil (U) = white (W) in RNA
 Uracil (U) = white (W) pairs with Adenine (A) = orange (O) in RNA
 Guanine (G) = green (G) pairs with Cytosine (C) = pink (P) in DNA & RNA
 Cytosine (C) = pink (P) pairs with Guanine (G) = green (G) in DNA & RNA

FUN FACTS:

- DNA was first discovered by biochemist Friedrich Miescher in 1869, but it wasn't until the 1940s that Oswald Avery realized DNA contains humans' genetic blueprint.
- Want to try typing out the human genome? Better get cracking: typing at 60 words per minute for eight hours a day, it would take about 50 years to finish.

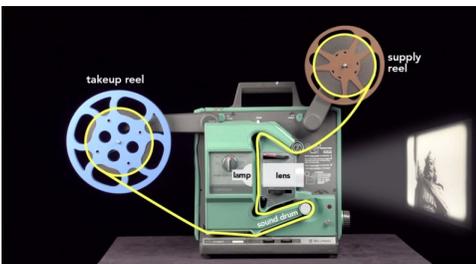
Factinate ; www.factinate.com/things/24-fascinating-facts-dna/

It is called **preRNA** until it is ready to make a protein.

- Use the **strand**:
5'—**ATAGGCCAAGAT**—3'
to make the **preRNA strand**.
- Cut the toothpicks in half. Attach **complementary nucleobases** to toothpicks on the **preRNA** licorice twist using the RNA code in the green box below.
- The **preRNA** is actually not yet complete. Some sections of **nucleobases** are removed and the **mRNA** is spliced back together. The front end of **mRNA** is “capped” (**5' cap** or **RNA cap**), and the 3' end has a **poly-A tail** added (100—250 adenine **nucleobases**). After editing, the **strand** is now **mRNA**. It exits the nucleus and enters the cell's **cytoplasm**. In our licorice/marshmallow model, we will assume that it represents a section in the middle of the gene that is not altered by this editing process.

Translation

- The **mRNA strand** contains directions for assembling a protein. Proteins are built from small molecules called **amino acids**. The **mRNA** is threaded, like film in an old fashioned movie projector.



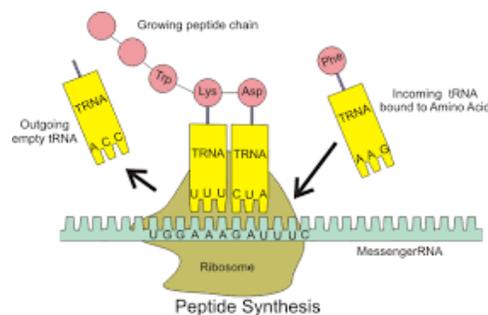
Of course the **mRNA** isn't threaded into a movie projector, but into a

macromolecule called a **ribosome**. The **ribosome** has two sections. The lower section is where the **mRNA** is seated presenting three **codons**, and the upper section has three slots. Each slot holds one **transfer RNA (tRNA)**; (definition page 6). Each **tRNA** has three **nucleobases** that are called **anticodons** (definition page 6). The three **nucleobase anticodons** code for one of the 21 different **amino acids** that make proteins in humans. The first slot seats the incoming **tRNA**. The second slot matches the **anticodon** to the **mRNA's codon** and attaches the amino acid. The third slot releases the **tRNA**.

- The process of assembling the growing protein is called **translation**.

Directions:

- Note: There are 22 total **amino acids**, 21 in humans. *Selenocysteine (Sel) was



FUN FACT:

- It wasn't until 2000 that scientists completed the first draft “map” of the human genome.

Factinate ; www.factinate.com/things/24-fascinating-facts-dna/

RNA—Marshmallow Color Code

Adenine (A) = orange (O) pairs with Uracil (U) = white (W) in RNA
 Uracil (U) = white (W) pairs with Adenine (A) = orange (O) in RNA
 Guanine (G) = green (G) pairs with Cytosine (C) = pink (P) in DNA & RNA
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POWER WORDS

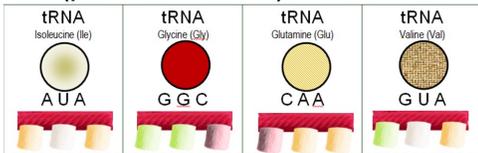
- **amino acid**: the building blocks of proteins, one of the major components a living cell
- **cytoplasm**: the material within a living cell, excluding the nucleus
- **messenger RNA**: RNA in which genetic information transcribed from DNA transferred to a ribosome to make a protein
- **mRNA**: messenger RNA
- **organelle**: organized or specialized structures within a living cell
- **RNA cap**: adding molecules to the 5' end of **preRNA** during the editing process
- **poly-A tail**: adding 100-250 adenine **nucleobases** to the end of **preRNA** during the editing process
- **ribosome**: bind mRNA and transfer RNA to synthesize proteins

recently found in humans. Our model includes 20 **amino acids**.

- The **cytoplasm** in the cell is crammed full of amino **acids**, organelles, and other items. A **tRNA** will find a specific **amino acid** to capture. It is then ready to enter the first slot of a ribosome, matching the

complementary three **nucleobases** on the **mRNA**.

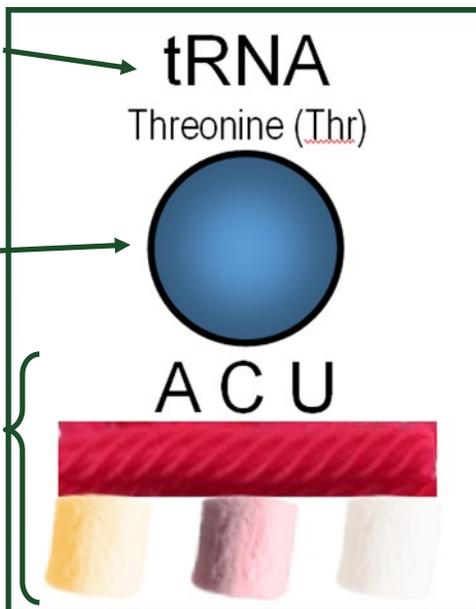
- Cut 1 licorice twist into 4 equal pieces.
- Cut 6 toothpicks in half with sharp scissors. It is easier to work with short toothpicks.
- Page 7 has the tRNAs that you need for this activity. Cut the first row along the dotted line. Use the top four (pictured below).



- Add licorice twist and mini-marshmallow **anticodons** on each of these strips, matching them exactly.
- The **mRNA** in the ribosome is read in **codons**, and **complementary** pair with the **tRNA anticodons** (image below of the model's **tRNA**). Your licorice twist **mRNA** has a total of 12 **nucleobases**, so your protein will be only four **amino acids** long. Each group of three is a “code” for a specific **amino acid**. If you correctly **transcribed** DNA to

Model for tRNA: tRNA binds with a specific amino acid. Example: the **codon** ACU bonds only with Threonine.

At the other end of the tRNA is the **anticodon**. It contains three **nucleobases** (here ACU) that pair with their complementary **mRNA** pair.



mRNA, the strip of 4 **tRNA** will **complementary** pair with the **mRNA**.

- Look at the first three **nucleobases** at the 5' end of your mRNA. You have the **complementary tRNA** to pair. (**mRNA** is UAU, and the **complementary tRNA** is AUA, **amino acid** Ile). That is your first protein. Continue verifying the 3 other mRNA and complementary tRNA's **codons**. The table below has the answers for this entire activity. Do you notice any patterns? The DNA and tRNA match (with U replacing T in the tRNA). The last column shows the final protein product of amino acids L Ile—Gly—Glu—Val
- The other three tRNA/amino acids shown on page 7 have one nucleobase substituted. Examine each and determine how the protein changes.
- Next month—mutations!

POWER WORDS

- **anticodon:** a sequence of three nucleotides forming a unit of genetic code in **tRNA**, corresponding to the **complementary codon** in **mRNA**
- **codon:** a sequence of three **nucleobases** which together form a unit of genetic code in **mRNA**
- **transfer RNA:** folded molecule which transport amino acids from the **cytoplasm** of a cell to the **ribosome**
- **tRNA:** transfer RNA

Transcription—DNA to mRNA.

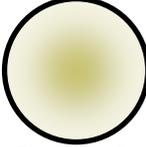
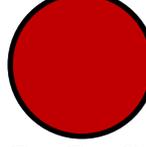
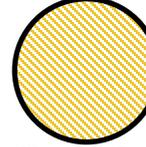
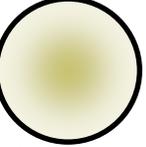
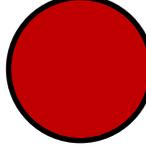
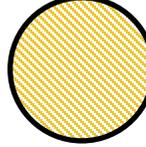
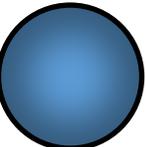
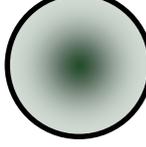
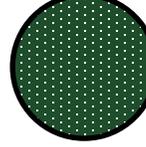
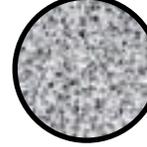
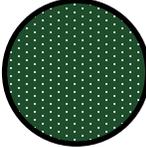
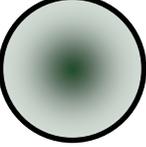
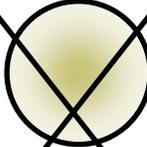
Translation—mRNA and tRNA to amino acids.

Answer key:

DNA	mRNA Codon	tRNA Anticodon	Amino Acid
ATA	UAU	AUA	Ile
GGC	CCG	GGC	Gly
CAA	GUU	CAA	Glu
GAT	CUA	GAU	Val

Marshmallow Color Code—RNA

Adenine (A) = orange (O) pairs with Uracil (U) = white (W)
 Uracil (U) = white (W) pairs with Adenine (A) = orange (O)
 Guanine (G) = green (G) pairs with Cytosine (C) = pink (P)
 Cytosine (C) = pink (P) pairs with Guanine (G) = green (G)

<p>tRNA Isoleucine (Ile)</p>  <p>A U A</p> 	<p>tRNA Glycine (Gly)</p>  <p>G G C</p> 	<p>tRNA Glutamine (Glu)</p>  <p>C A A</p> 	<p>tRNA Valine (Val)</p>  <p>G U A</p> 
<p>tRNA Isoleucine (Ile)</p>  <p>A U <u>C</u></p> 	<p>tRNA Glycine (Gly)</p>  <p>G G <u>G</u></p> 	<p>tRNA Glutamine (Glu)</p>  <p>C A <u>G</u></p> 	<p>tRNA Valine (Val)</p>  <p>G U <u>C</u></p> 
<p>tRNA Threonine (Thr)</p>  <p>A <u>C</u> A</p> 	<p>tRNA Valine (Val)</p>  <p>G <u>U</u> C</p> 	<p>tRNA Leucine (Leu)</p>  <p>C <u>U</u> A</p> 	<p>tRNA Glutamic Acid (Glu)</p>  <p>G <u>A</u> A</p> 
<p>tRNA Leucine (Leu)</p>  <p><u>U</u> U A</p> 	<p>tRNA Arginine (Arg)</p>  <p><u>C</u> G C</p> 	<p>tRNA STOP</p>  <p><u>U</u> A A</p> 	<p>tRNA Isoleucine (Ile)</p>  <p>A U A</p> 

RNA Translation to Proteins:

When the **preRNA** editing is complete, the **mRNA** exits the nucleus and enters into the **cytoplasm** (everything in the cell except the nucleus).

Like the nucleus, the **cytoplasm** is packed full. Instead of DNA, it contains **macromolecules**, ATP (energy packets), **organelles**, and raw materials.

The **mRNA** carries directions for making a **protein**. Basically, **proteins** make everything we need to be an organism. They are comprised of **amino acids**. There are a total of 21 **amino acids** in humans (the 21st was recently discovered).

RNA has several forms to do

complementary three **nucleobases** on the **mRNA** held by a **ribosome**.

The a huge **ribosome macromolecule** has two sections that fit together. That is where **mRNA**, and **tRNA** meet, and the three **complementary nucleobases** bind.

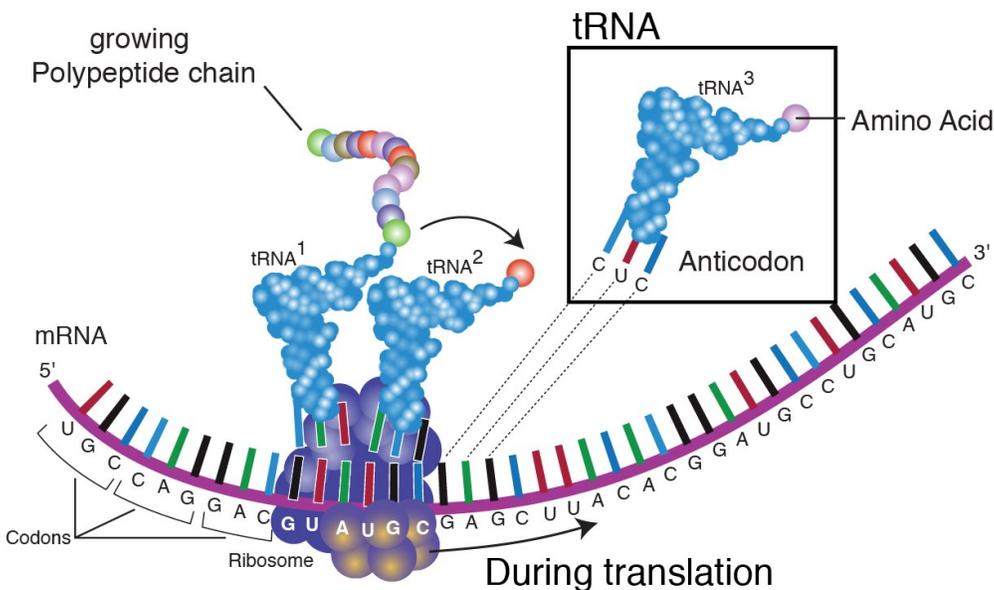
On the smaller section, **mRNA** is threaded into the ribosome, and is pulled in the 5' to the 3' direction. If you have ever seen an old-fashioned movie projector, it is a similar to that. On the larger section of the ribosome, there are three ports to hold 1 **tRNA**. The port allows the 3 exposed **nucleobases** to find the **complementary nucleobases** on **mRNA**.

FYI:

The focus of the Paleontology issues are primarily the animal fossil record, the DNA tutorial will focus on animal cells and DNA.

ANCIENT DNA:

Last year, a team announced a revolutionary method to analyze DNA from much more ancient species. Instead of using DNA, the scientists sequenced tooth enamel from a species of rhino that lived 1.7 **MYA**. DNA transcribes RNA, and RNA is the template for proteins. by reverse-engineering the protein, they can determine at least 2 out of every three **nucleobases** of the codon.



The first port hold the incoming tRNA. It shifts to the second port, where it donates the amino acid to the growing protein. The It shifts to the third port, which releases the **tRNA** (no longer carrying the **amino acid**). The image on the left, the chain of amino acids has not yet attached to the new amino acid. **tRNA** would then be released.

different tasks in the cell.

Besides mRNA, there is also **transport RNA (tRNA)** found in the **cytoplasm**. The **tRNA** finds and binds with a different **amino acid**, one of the raw materials a cell needs to function. There is three exposed **nucleobases** on **tRNA** ready to find the

FUN FACTS:

- About 5% of the weight of a human cell is RNA. Only about 1% of a cell consists of DNA.
- RNA is found in both the nucleus and cytoplasm of humans cells. DNA is only found in the cell nucleus.
- RNA is the genetic material for some organisms which don't have DNA. Some viruses contain DNA; many only contain RNA.

mRNA Codon/Amino Acid Chart

First Base	Second Base				Third Base		
	U	C	A	G			
U	UUU — Phenylalanine (Phe) UUC — Phenylalanine (Phe)	UCU — Serine (Ser) UCC — Serine (Ser) UCA — Serine (Ser) UCG — Serine (Ser)	UAU — Tyrosine (Tyr) UAC — Tyrosine (Tyr) UAA — Stop UAG — Stop	UGU — Cysteine (Cys) UGC — Cysteine (Cys) UGA — Stop UGG — Tryptophan (Trp)	U C A G		
	C	CUU — Leucine (Leu) CUC — Leucine (Leu) CUA — Leucine (Leu) CUG — Leucine (Leu)	CCU — Proline (Pro) CCC — Proline (Pro) CCA — Proline (Pro) CCG — Proline (Pro)	CAU — Histidine (His) CAC — Histidine (His) CAA — Glutamine (Glu) CAG — Glutamine (Glu)	CGU — Arginine (Arg) CGC — Arginine (Arg) CGA — Arginine (Arg) CGG — Arginine (Arg)	U C A G	
		A	AUU — Isoleucine (Ile) AUC — Isoleucine (Ile) AUA — Isoleucine (Ile) AUG — Start Methionine (Met)	ACU — Threonine (Thr) ACC — Threonine (Thr) ACA — Threonine (Thr) ACG — Threonine (Thr)	AAU — Asparagine (Asn) AAC — Asparagine (Asn) AAA — Lysine (Lys) AAG — Lysine (Lys)	AGU — Serine (Ser) AGC — Serine (Ser) AGA — Arginine (Arg) AGG — Arginine (Arg)	U C A G
			G	GUU — Valine (Val) GUC — Valine (Val) GUA — Valine (Val) GUG — Valine (Val)	GCU — Alanine (Ala) GCC — Alanine (Ala) GCA — Alanine (Ala) GCG — Alanine (Ala)	GAU — Aspartic Acid (Asp) GAC — Aspartic Acid (Asp) GAA — Glutamic Acid (Glu) GAG — Glutamic Acid (Glu)	GGU — Glycine (Gly) GGC — Glycine (Gly) GGA — Glycine (Gly) GGG — Glycine (Gly)

Amino Acid	Symbol
Alanine	Ala
Arginine	Arg
Asparagine	Asn
Aspartic acid	Asp
Cysteine	Cys
Glutamic acid	Glu
Glutamine	Gln
Glycine	Gly
Histidine	His
Isoleucine	Ile
Leucine	Leu
Lysine	Lys
Methionine	Met
Phenylalanine	Phe
Proline	Pro
*Selenocysteine	Sec
Serine	Ser
Threonine	Thr
Tryptophan	Trp
Tyrosine	Tyr
Valine	Val

How does mRNA code for the specific amino acid that it needs to complete the correct protein? Glad you asked!

It is like a spy game of code breaking. The above table shows the combination of three **nucleobases** (called a **codon**) that will find the corresponding **amino acid** on **tRNA**. The **nucleobases** have a total of 64 different combination. There are only 21 **amino acids**. That means there is wiggle room. Both **tRNA codons** UUU and UUC will find the amino acid Phenylalanine (Phe), or the **tRNA codons** CUU, CUC, CUA, or CUG code for Leucine (Leu). One **codon**, AUG, starts the protein building, and also codes for Methionine (MET). There are 3 **codons** that indicate the end of the protein building, UAA, UAG, and UGA.

Just as the **nucleobases** are abbreviated ATGCU, the **amino**

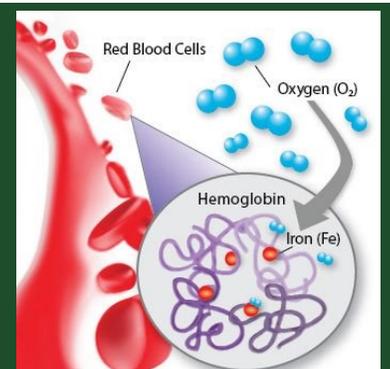
acids are abbreviate by 3 letters. The table in the green box on the right includes the full amino acid name and the abbreviation. The abbreviations will only be used after this. The 21 amino acids can form over 6 million proteins. As the protein is being formed, it starts to fold into the final structure that it will take. Each amino acid has a different property. Some are basic and other acidic, some are polar (negative or positive that act like magnets), and some are neutral. The interactions shape the protein.

Practice reading codons:

- What amino acid pairs with the codon ACU?
- Which codons are paired with Lys?
- Which amino acid pairs with the codon UAG?
- Which codons are paired with Ala?

Answers on page 25.

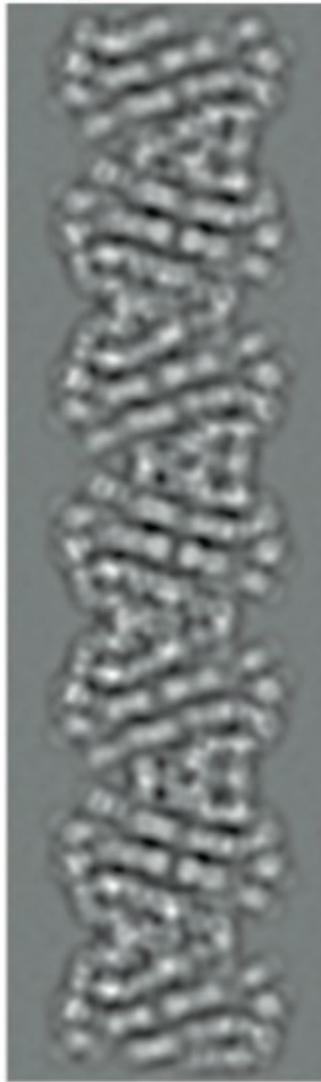
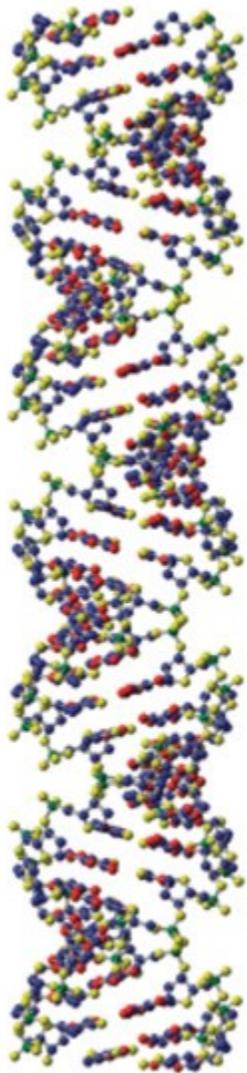
Hemoglobin: the protein carries oxygen in red blood cells. Composed of 574 amino acids in the 4 subunits, they trap iron atoms to hold oxygen for transport in blood vessels.



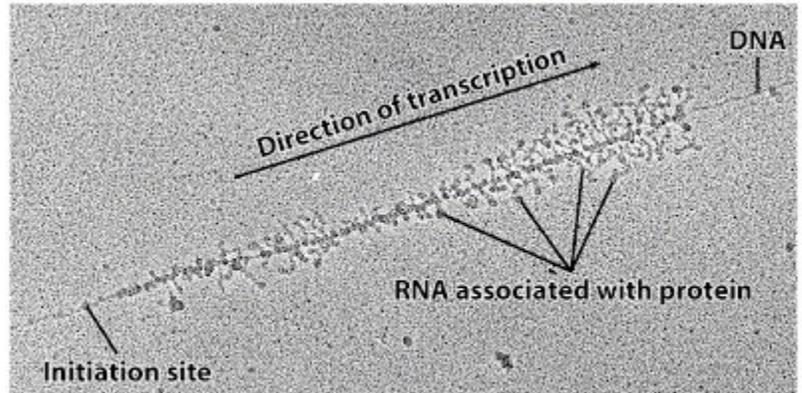
DNA in the Cell:

Model

Micrograph



DNA Transcribing preRNA



When DNA transcription makes preRNA, it does not complete one at a time. Instead, it is like a conveyor belt. The RNA polymerase (molecule that building RNA from DNA) constantly finds the initiation site when it is available, and zips along the DNA to completion.

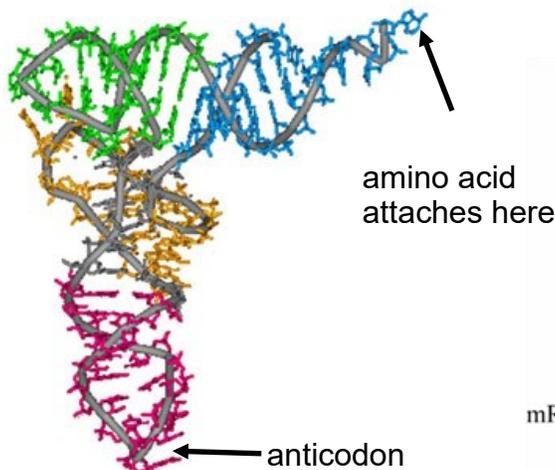
On the micrograph (microscopic image) above, you can see dozens of preRNA being made, lagging just behind the one in front. The RNA polymerase is moving from left to right. The preRNA grows longer as you move to the right. The cell becomes flooded with the protein, until the need is met, and then the gene is switched off.

Since the mRNA and tRNA are made with unstable uracil nucleobase, it breaks down rapidly. This helps the cell better control our metabolic functions.

Transcription is a really fast process. The RNA polymerase races along the DNA at incredible speed.

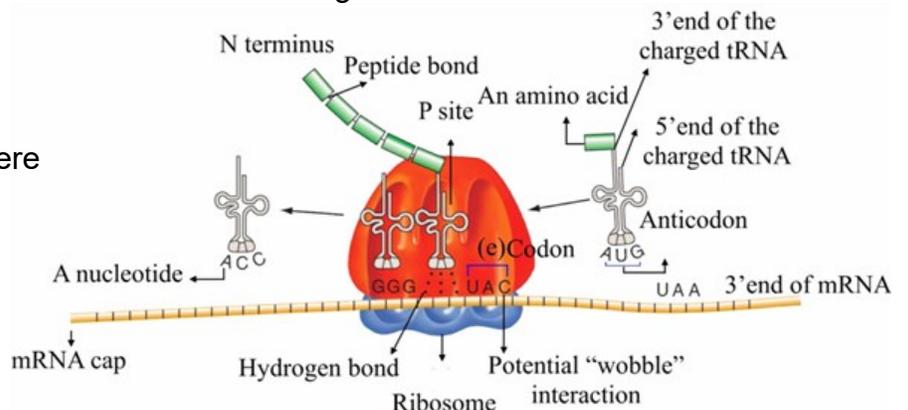
tRNA model

(too small to be seen in microscopes)



Ribosome

Blue is lower subunit, pulling mRNA. Red is upper subunit with the growing green protein and the tRNA matching its anticodon to mRNA's codon.



Triassic (251—200 MYA):

The world **transitioned** from the Great Dying to the Triassic with Pangaea in place, the atmosphere slowly recovering, and life slowly rebounding.

Gymnosperms dominated the landscape with ginkgo, cycads, conifers, and Bennettitales (an extinct order of seed plants).



Cycad

During the Triassic, new lineages of animals begin to appear, including reptiles and amphibians. One of the earliest fossils of a dinosaur is 231 MYA from Argentina called *Eoraptor*.

The first true mammal fossils appeared during this time. They were small and shrew-like. Their distant cousins, the synapsids, survived the P-Tr boundary (good thing for us!)

Jurassic (200—145 MYA):

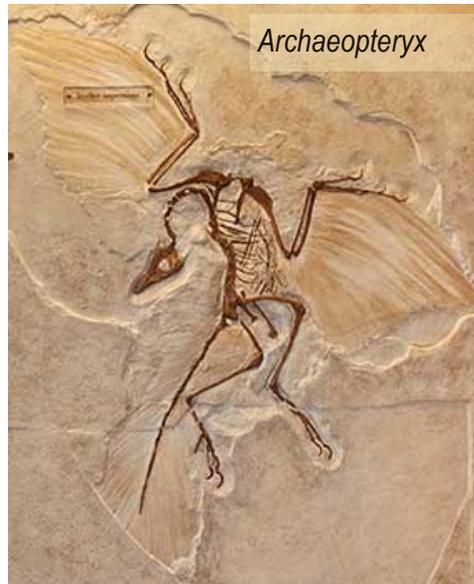
The interior Pangaea was still hot and dry. Pangaea began to separate into **Laurasia** and **Gondwana**. China was battered by **monsoons**. Towards the end of this Period, the poles began to cool.

Gymnosperms and ferns were the dominant plant life.

This was the time of dinosaurs, and enormous dinosaurs—the sauropods. These enormous

animals probably reached the upper limits of how big terrestrial animals can be. Cool! There were massive dinosaur predators, like Allosaurus. Flying reptiles, the pterosaurs, and a host of marine reptiles, like ichthyosaurs.

The first true birds appear in the fossil record from the Jurassic. Probably the most famous (and one of the earliest) is from the German Messel Fossil Beds, the *Archaeopteryx*.



Archaeopteryx

Cretaceous (145—66 MYA):

Laurasia and **Gondwana** began to separate into the modern continents. The start of this Period was a mild “Ice House” and by the end, was warm and wet.

Flowering plants appear! Dinosaurs still diversified.

Ammonites, mollusks, and fish were hunted by enormous



Triceratops

POWER WORDS

- **Gondwana:** southern hemisphere super-continent formed by South America, Africa, Antarctica, and Australia
- **gymnosperm:** literally means “naked seed” includes conifers, ginkgo, cycads, etc.
- **Laurasia:** northern hemisphere super-continent formed by North America, Europe, and Asia
- **monsoon:** heavy rains
- **terrestrial:** of or relating to the Earth
- **transition:** the process of changing from one state or condition to another

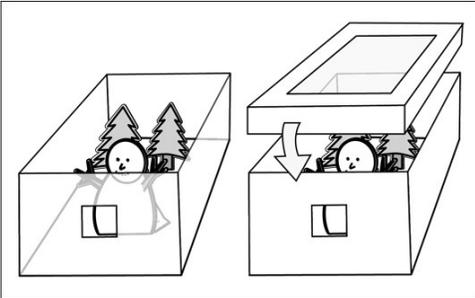
marine reptiles, and skies were ruled by pterosaurs.

Insects diversified including the first butterflies and ants.

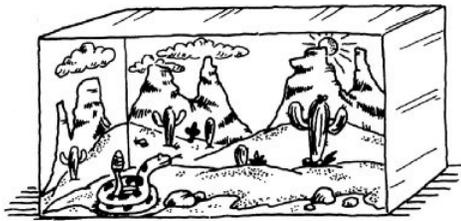
And then, it all ended with a bang 66 MYA with the KT extinction!

It is probably no surprise that when I was your age, I LOVED making dioramas. Guess what!

There are two types of **dioramas**, each using a different **orientation** of the box. One is the peephole **diorama**. The advantage is a truly 3D world.



The other type of **diorama** is the open box scene. It provides interest in the full scape.



Using everyday materials, like paper, paint, and pebbles, you can create wonderful **dioramas!**

Directions:

- Each shoebox represents a different Period in the Mesozoic Era:
 - Triassic
 - Jurassic
 - Cretaceous
- Research information about each Period online. The prior page includes brief summaries of the major features of the land and a bit about the oceans during the Mesozoic. Fill in with more specific information.
- Verify that your website is

from either a university or natural history museum to ensure that your information is authentic. For example, the University of Michigan, the Smithsonian, and the American Museum of Natural History have great information.

- The websites listed in the green boxes on pages 13 and 14 were selected to give you ideas for building each **diorama's** landscape. For example, trees (website 8), horsetails (very similar to bamboo website 9), mountains (website 3, 4, and 5), or water (website 6 and 7). The first website has complete directions for how to build a **diorama**, including selecting good boxes. The second website takes you from beginning to end on a Sierra Mountain **diorama**. It has lots of great tips for you.
- The basic steps to building a **diorama**:
 1. select a simple sturdy shoe box with a lid
 2. paint the outside and label what will be inside
 3. Paint the interior of the shoe box with the background
 4. build the topography, the hills, mountains, streams, etc.
 5. add water to streams,

POWER WORDS

- **diorama**: a model representing a scene with three-dimensional figures, either in miniature or as a large-scale museum exhibit; a scenic painting, viewed through a peephole, in which changes in color and direction of illumination simulate changes in the weather, time of day, etc.
- **orientation**: relative position of something

- 6. add vegetation
- 7. add animals
- Start with the Triassic. Take notes and make sketches of the information as you find it. When you have enough information about the climate, landscape, plants and animals, sketch what you would like your final

MATERIALS

- computer with internet
- 3 sturdy shoeboxes with separate lids
- playdough, plaster of Paris, or papier mâché
- art supplies (e.g. tape, scissors, markers, glue, poster paint, tissue paper, etc.)
- craft knife or box cutter (& parent supervision)
- cellophane wrap (party section of store)
- lots of creativity and imagination

diorama for that Period to look like.

- You can either complete each **diorama** one at a time, or work on all three of them in stages. For example, paint all of the boxes on the outside, and allow them to dry. Label each of them a different Period. Paint the interior of the boxes. Build the topography in all three. We all approach creativity differently, so approach these dioramas with what makes sense to you.
- Select sturdy, simple shoeboxes with lids. If possible, use 3 identical boxes. Shoe stores have extra boxes and will save them for you if you ask.
- Paint the outside of the shoebox with spray paint,

open box **diorama**. If you want to make a peephole **diorama**, you need to constantly refer to close and far from the peephole. You don't want something large in front blocking the view.

- Paint the inside of the box with the distant scene. Perhaps you are overlooking the ocean from a cliff. The background would be the ocean, horizon, and sky. If you are looking inland, it could be a distant mountain range.
- Create your **topography** for each scene. For example, website 2 uses plastic cups that are then covered with paper mâché. You can use recycled **corrugated** cardboard boxes cut to give the overall shape (image



poster (tempera) paint, or wrap with paper, like a present. Allow the paint to dry completely. Using a **contrasting** color marker or poster paint, write the name of the Period (**e.g.** “Cambrian”).

- The directions are for the

POWER WORDS

- **contrast**: strikingly different from something else
- **corrugated** : material, surface, or structure shaped into alternate ridges and grooves
- **topography**: the arrangement of the natural and artificial physical features of an area

below; see <https://tra.extension.colostate.edu/stem-k12/stem-resources/> 47. Here Comes the Sun pages 19-22 for directions), which can then be covered with paper mâché, aluminum foil, or homemade playdough (see <https://tra.extension.colostate.edu/stem-k12/stem->

WEBSITES

How to:

1. https://www.youtube.com/results?search_query=Stephanie+Barnett+diorama
2. <https://www.youtube.com/watch?v=6ganUXUa0sw>

Topography:

3. <https://www.youtube.com/watch?v=os1SA2ZpVdE>
4. <https://www.youtube.com/watch?v=uK0XcoUX9u0>
5. <https://www.youtube.com/watch?v=pm-wEpu1yBo>

[resources/](#) 57.Paleontology 5, page 6 for directions to make playdough). You can carve your terrain from recycled foam (website 11).

- Allow the paper mâché or playdough to dry completely before painting.
- Paint your **terrain**. Websites 3, 6, and 10 have ideas. Also <https://tra.extension.colostate.edu/stem-k12/stem-resources/> 42.Pigments has ideas for making your own paint pigments from natural sources, like our red rock mountains. There is also a Munsell color chart that you can use to get more realistic soil colors.
- Include the dominant plants and other typical vegetation of that Period (remember, no flowering plants until the Cretaceous). One of the oldest flowering plants is the magnolia (image below).



- Add animals that were found during that time, sculpted from homemade playdough or paper mâché covered aluminum foil shaped like these organisms. The websites below will get you started with fauna and flora.

The diorama pictured on the right is from the Milwaukee Public Museum, the Natural History in Wisconsin. It depicts the Cretaceous Period with a *T.*

rex eating a *Triceratops* in the **foreground**. The background depicts plants. Gymnosperms were still common, but flowering plants also appear.

What colors were the animals from the Mesozoic? There are impressions of dinosaur skin, so we know they were scaly. They could have had similar colors to similar animals found today. No one knows, yet, but scientists are getting closer to knowing some of those colors.



Sinosauropteryx was a feathered dinosaur. Scientists have found melanosomes, or cells that generate color. These small (3 feet) dinosaurs had a “robber mask” over their eyes, reddish coloration on their back, pale belly, and striped tails (image on right). Way cool!



**Have fun! Learn lots!
Science is awesome!**

POWER WORDS

- **foreground**: the part of a view that is nearest to the observer

Water:

6. <https://www.youtube.com/watch?v=NwXBvc-FmhU>

7. <https://www.youtube.com/watch?v=MbjF4oaZ6hQ>

Vegetation:

8. <https://www.youtube.com/watch?v=UdvwhJoYqAM>

9. <https://www.youtube.com/watch?v=Jw-CaMe6ltE>

Paper Mâché Clay

10. <https://www.youtube.com/watch?v=1YQ6eUqcEh8>

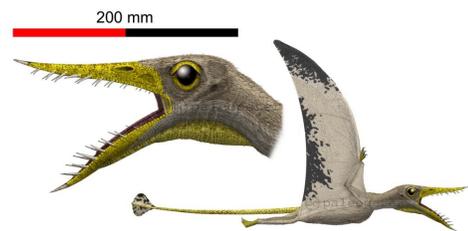
This month, you will complete the Mesozoic Era on your Timeline. Next month, the issue will focus on mutations and Dinosaurs.



Fossil Grasshopper from Late Triassic

In this activity, you will explore the internet to locate the oldest record known of various organisms from this time era. You will find basic information about each Period's climate and organisms on page 11 to get you started. You also have the climate and continents' location on your timeline.

The diversity of life is truly wondrous. Every Era has amazing, weird and wonderful (even terrifying) animals. The Mesozoic Era perhaps hold the record for terrifying and fierce animals that ruled the oceans, lands, and skies.

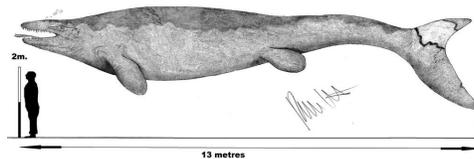


Rhamphorhynchus muensteri

You certainly do not need to find every single organism on this list, but you may...just may...get pulled into this incredible time! It is, after all, the closest thing we do have to a time machine. So, get ready for wonder!



Mosasaurus hoffmannii



This list does not include bacteria, archaea, protists (organisms with eukaryote cells, but they are mostly single celled organisms), or fungi. These organisms were certainly present in abundance. There are some plants in the table, but most of the organisms are animals.

Put on your "This is Truly Amazing" hat, and get ready for wonder!

Directions:

- The list of organisms is not

FUN FACT:

- Pterosaurs were NOT dinosaurs.
- The smallest Pterosaur was *Nemicolopterus cryptus*, the size of a finch to *Quetzalcoatlus northropi*, with a wingspan greater than 33 feet!
- Pterosaurs walked on all fours, folding up their wings like umbrellas.
- Pterosaurs were fluffy, which means they were probably warm-blooded, like bats and birds.
- Pterosaur bones were hollow, with walls as thin as playing cards. Like bird's bones, they were strengthened by internal struts.
- Pterosaurs lived from 220 to 66 MYA.

comprehensive by any means, but it includes a variety of animals and plants.

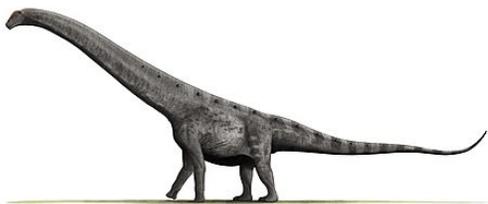
- The table on page 18-19 has one of the first fossils found for representatives of the vertebrate groups and some invertebrate groups. Include each of those on your timeline.
- The tables on pages 20—

MATERIALS

- your Phanerozoic Eon timeline
- sharpies or markers in a variety of colors
- pencil
- yardstick or meterstick
- computer with internet
- printer (color optional)
- glue stick or tape
- print pages 18-23 double-sided
- art supplies (optional)

23 includes additional species. Select at least 3 organisms from each group. Complete the table.

- Search the internet to locate an image and information about each organism.
- Copy / paste the image to a word document, and resize it to fit on your timeline. For example, you could make your images each 3" x 3" (or so). Since that does not convey the proper scale, note the size next to the image. Examples:
 - *Argentinosaurus* (image above) 120 feet long, and stood 70 feet high; Late Cretaceous; from Argentina



- *Microraptor* (image right) 2.5 feet; Early Cretaceous—had 4 wings (both arms and legs); from China



- Do not tape or glue down anything yet. Wait until you have completed your table and images of all the organisms you are adding to your timeline.
- Once you are done, place all the images in the correct Period. Arrange them until you like how it looks. Tape or glue all your images.
- Include information (like size) by each image.
- If you found the range the species fossils lived, you can indicate that with a **vertical** line that starts at their first (origin) fossil occurrence, and their last (extinction) fossil occurrence. Use the yard or meter stick to connect the origin and extinction points. As an example, the diagram of the Paleozoic timeline has the time range of Class Trilobita's origin and extinction indicated by the green-blue oval.

FUN FACT:

- Dinosaur fossils have been found on all seven continents.
- There are about 700 known species of dinosaurs.

Paleozoic Era	Permian 252 - 299 MYA	Late & Middle Permian: Equatorial rainforest disappeared as deserts spread across central Pangea. Though...		
	Carboniferous Upper (Pennsylv)	North Pole. Rainfor...		
	Carboniferous Lower (Mississippian) 323 - 359 MYA	sts covered South China and it crossed the Equator.		<i>Protolitaops jakutensis</i>
	Devonian 359 - 419 MYA	Early Permian: Much of the Southern Hemisphere was covered by ice as glaciers pushed northward. Coal was produced in both		Oldest trilobite 521 MYA. <i>Protolitaops jakutensis</i>
	Silurian 417 - 443 MYA	Equatorial rainforests an...		
	Ordovician 443 - 485 MYA	in temperate forests during the warmer "interglacial" periods.		
	Cambrian 485 - 540 MYA			

Keep your timeline until May. You will complete the Cenozoic Era.

FUN FACT:

- The heaviest dinosaur was the *Argentinosaurus*.
- The smallest dinosaur is the hummingbird! The smallest adult dinosaur fossil is *Lesothosaurus*. *Microraptor* was also very small.
- The dinosaur with the most brain capacity was the *Troodon*. It was about 6' long, and had the brain size similar to modern mammals.

- As you collect images of each organism, be sure to identify it on your word document.
- When you have found all the animals and plants you want to include on your timeline, cut out them with scissors.

Directions:

- Copy the name of the fossil, and paste into your search engine. That will begin your journey into the life of the Paleozoic!
- To gain a better understanding of the wonderful and bizarre animals and plants from the past, check them all out.
- Add at least two of these species for each Period on your time line.
- HAVE FUN!

Triassic Period—select at least three of the following:

- *Apleuroceras* sp.
- *Caseodus* sp.
- *Coelacanthus banffensis*
- *Eocorona iani*
- *Hauffiosaurus* sp.
- *Lisowicia bojani*
- *Lystrosaurus* sp.
- *Mastodonsaurus giganteus*
- *Morganucodon watsoni*
- *Oligokyphus* sp.
- *Selenocara groenlandica*

Dinosaurs—select all:

- *Coelophys* sp.
- *Herrerasaurus* sp.
- *Melanorosaurus* sp.
- *Nyasasaurus parringtoni*

Jurassic Period—select at least three of the following (all fossils found in Colorado!):

- *Amblotherium gracilis*
- *Amphicotylus lucasii*
- *Compsemys plicatulus*
- *Diablophis gilmorei*
- *Eilenodon robustus*
- *Eobatrachus* sp.
- *Fruitafossor windscheffeli*
- *Glirodon grandis*
- *Glyptops plicatulus*
- *Hallopus victor*
- *Hulettia hawesi*
- *Kepodactylus insperatus*

- *Mesadactylus ornighosphyos*
- *Morrolepis schaefferi*
- *Opisthias rarus*
- *Parapleurites morrisonensis*
- *Priacodon fruitaensis*
- *Saurillodon* sp.
- *Tektonargus kollaspilus*

Dinosaurs—select at least 4:

- *Allosaurus* sp.
- *Cryolophosaurus* sp.
- *Dilophosaurus* sp.
- *Megalosaurus* sp.
- *Scelidosaurus* sp.
- *Stegosaurus* sp.
- *Yuanmousaurus* sp.

Cretaceous Period—select at least three of the following:

- *Archaeofructus liaoningensis*
- *Beelzebufo ampinga*
- *Dolichorhynchops bonneri*
- *Homeosaurus maximiliani*
- *Jeholopterus* sp.
- *Manipulator modificaputis*
- *Maothierium asiaticus*
- *Megaxantho zogue*
- *Mesophtirus engeli*
- *Paraclytia valashtensis*
- *Rugosodon eurasiaticus*
- *Vintana sertichi*

Dinosaurs—select at least 4:

- *Deinonychus* sp.
- *Hadrosaurus*
- *Malawisaurus* sp.
- *Parasaurolophus* sp.
- *Triceretops* sp.
- *Tyrannosaurus* sp.
- *Velociraptor* sp.

FUN FACT:

- The Mesozoic is known as the Age of Dinosaurs, and also the Age of Conifers.
- It lasted 186 million years. 186,000,000 seconds is almost 5 years.
- In 1840, British geologist John Phillips proposed the name Mesozoic. The word Mesozoic is derived from the Greek language and means middle life.
- The Mesozoic Era ended 66 MYA. There is strong evidence of a huge meteor striking the Earth at Chicxulub, Mexico at that time.

**FUN CRAFT:**

- The coolest optical illusion—*T rex* head will follow you where ever you go!
<https://www.youtube.com/watch?v=A4QcyW-qTUg>
- template (scroll down to the bottom and click “Green,” “Red,” or “Blue”:
<https://gawker.com/amazing-t-rex-illusion-lives-up-to-every-one-of-its-pro-1489087543>
- directions:: (click on one of the dragons—directions are on the template): <https://www.moillusions.com/dragon-illusion/>

- Include all of the organisms in this table on your timeline. They represent the some of the oldest fossils in the major **phyla** (plural of phylum). Search for as much information as you can find to complete your table. You may not be able to find everything. Leave that cell blank.
 - On the back of your table, include interesting information about each species; e.g. *Nyasasaurus parringtoni* was found 100 years before it was studied.
- Power Words:**
- **Class:** classification of organisms, it falls below Domain, Kingdom, and Phylum
 - **Phylum:** a principal taxonomic category that ranks above class and below kingdom (botanists use the word “division” instead)

First Fossil Evidence in the Paleozoic Era					
Organism	Period	Time Range	Phylum	Class	Size
Example: first dinosaur? <u><i>Nyasasaurus parringtoni</i></u>	Triassic	243 MYA (no range given)	Chordata	Reptilia	2-3 m (6—10 feet)
Pterosaur <i>Caelestiventus hanseni</i>					
Ichthyosaur: <i>Grippia longirostris</i>					
Plesiosaur: <i>Rhaeticosaurus mertensi</i>					
Sauropod: <i>Antetonitrus ingenipes</i>					
Sauropsida (reptile): <i>Isisfordia</i>					
Synapsida: <i>Montirictus kuwajimaensis</i>					
Mammal: <i>Juramaia sinensis</i>					
Bird: <i>Aurornis xui</i>					
Plants: <i>Pleuromeia</i> sp.					
Plants: <i>Montsechia vidalii</i>					

First Fossil Evidence in the Paleozoic Era	
Organism	Interesting Facts
Example: first dinosaur? <u><i>Nyasasaurus parringtoni</i></u>	Found in 1930 in Tanzania, but the fossils were not studied until 2012. Scientists found that this could be the oldest known dinosaur. Only an upper arm bone and some vertebrae were found.
Pterosaur: <i>Caelestiventus hanseni</i>	
Ichthyosaur: <i>Grippia longirostris</i>	
Plesiosaur: <i>Rhaeticosaurus mertensi</i>	
Sauropod: <i>Antetonitrus ingenipes</i>	
Sauropsida (reptile): <i>Isisfordia</i>	
Synapsida: <i>Montirictus kuwajimaensis</i>	
Mammal: <i>Juramaia sinensis</i>	
Bird: <i>Aurornis xui</i>	
Plants: <i>Pleuromeia</i> sp.	
Plants: <i>Montsechia vidalii</i>	

In this year’s ST[EMpower] issues, you took and analyzed an interest survey. You also took a personality test. You can keep all your information in a career journal. You need your career information and your journal for this activity.

If you haven’t completed these yet, they are located here: <https://tra.extension.colostate.edu/stem-k12/stem-resources/>

- 53 Paleontology 1: Interest Survey starting on page 31
- 54 Paleontology 2: Interest Survey Results starting on page 50
- 55 Paleontology 3: Military Career Interest Survey on page 22 (optional for this activity)
- 56 Paleontology 4: Personality Test on page 14
- 57 Paleontology 5: Career Satisfaction on page 24

The interest survey analyzed twelve broad categories:

- Adventure
- Animals and Nature
- Art
- Business
- Computers
- Math
- Music and Dance
- Science
- Sports
- Talking
- Travel
- Writing

What are your four top ranked interests from your quiz results:

- 1.
- 2.
- 3.
- 4.

Look at your ranking. What are your top 3 or 4 categories? For example, my top 4 are Animals and Nature, Math, Science, and Travel. I love my job, and it incorporates all four of those interests. I am a paleontologist and I travel throughout the USA and South America to collect data on how a variety of different ancient mammals walked.

Personality tests provide insight in how you **perceive** the world, and how those **perceptions** influence your decisions. One of the first and most famous tests is Myer-Briggs, that evaluates responses on a scale of 4 different criteria:

- “E” Extraversion—“I” Introversion
- “S” Sensing—“N” Intuition
- “T” Thinking—“F” Feeling
- “J” Judgement—“P” Perception

The tests then provides a 4 letter code with 16 different combinations:

ESTJ	ENTJ	ISTJ	INTJ
ESTP	ENTP	ISTP	INTP
ESFJ	ENFJ	ISFJ	INFJ
ESFP	ENFP	ISFP	INFP

What is your personality test result?

Last month’s career project was to further incorporate both your personality and interests.

HIGHEST PAYING ART CAREERS

- Art Director
- Art Agent / Business Manager
- Art Professor
- Commercial Artist
- Animator
- Interior Designer
- Graphic Designer
- Art Gallery Dealer
- Advertising Designer
- Freelance Writer

HIGHEST PAYING JOBS

- Physician
- Pharmacy Manager
- Dentist
- Pharmacist
- Enterprise Architect
- Corporate Counsel
- Software Engineer
- Physician Assistant
- Corporate Controller
- Software Development Manager

Believe it or not, this is the first step in exploring a satisfying career! You selected a project (or developed your own) to explore these aspects of who you are. This month, you will evaluate your project and start looking at careers that incorporate the same talents and skills.

Awesome!

MATERIALS

- computer with internet
- pencil, pen, color pencils, markers
- your career journal

Record your responses in your career journal. Which project did you select?:

- Evaluate your favorite TV shows to find your interests
- Write a story about yourself in the future
- Design an art piece or machine from recycled materials
- Journal your activities over the month
- Develop a Hands, Head, Heart, Health Day of activities for younger members in your 4-H club
- Plan the perfect vacation
- Design your own adventure:

Did you have fun? _____

Why or why not? _____

What was the easiest part of your project?

What was the most difficult part of your project?

What would you change?

What would you keep?

Look at your interests and personality. Keep those in mind. Design a new project that incorporates those interests. Spend time online searching careers that are of interest to shape your project. Examples, if you top three interest are:

- adventure, animals and nature and art, your project could be taking images or sketching wildlife.
- art, talking, and writing, write a skit, cast your friends, and present your skit to your 4-H club or school

CAREER SITES

- Outdoor careers, work with national parks (Awesome site) <https://www.coolworks.com/jobs-by/national-park>
- United States Geological Survey (USGS) has wide variety of great careers <https://www.usgs.gov/about/organization/science-support/human-capital/employment-and-information-center>
- United States Department of Agriculture (USDA) careers are fascinating! <https://www.usda.gov/our-agency/careers>

Search the internet for your own dream career. What education and skills are required.

EXPERIENTIAL LEARNING

Learn by doing...that is the 4-H way of exploring projects. It also models one of the most effective ways to learn.

DO	REFLECT	APPLY
Try it out	Think about it	Use what you learn

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ACKNOWLEDGMENTS

- Funding for this project provided by Colorado State University System Venture Capital Fund
- CJ Mucklow, Colorado State University Extension Western Regional Director
- Dr. Joe Cannon and Marketing Strategies students Berlyn Anderson, Jenna Balsley, Rachel Kassirer, Rachel Richman, Colorado State University, College of Business, for marketing strategies and ST[EMpower] graphics
- Doug Garcia, Colorado State University Creative Services Communication Coordinator/ Designer

CITATIONS

Information:

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Images:

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- Timeline: http://www.fossilmuseum.net/Fossil_Sites/Santana-Formation/grasshopper/Eicanidae.htm; <https://www.amnh.org/explore/news-blogs/on-exhibit-posts/why-are-pterosaur-fossils-so-rare-video>; <https://www.newdinosaurs.com/rhamphorhynchus/>; <https://en.wikipedia.org/wiki/Mosasaurus>; <https://www.deviantart.com/teratophoneus/art/Mosasaurus-hoffmannii-741746440>

Answers for questions on page 9:

- What amino acid pairs with the codon ACU?
Thr (Threonine)
- Which codons are paired with Lys (Lysine)?
AAA and AAG
- Which amino acid pairs with the codon UAG?
Stop—no amino acids
- Which codons are paired with Ala (Alanine)?
GCU, GCC, GCA, and GCG