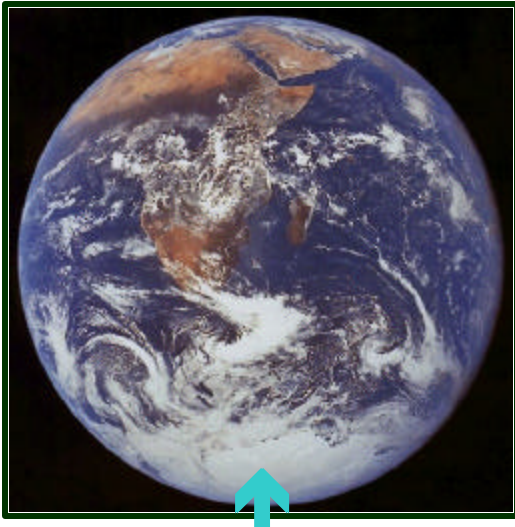


GOING FROM SEEDS TO STARS IN THE MILKY WAY GALAXY

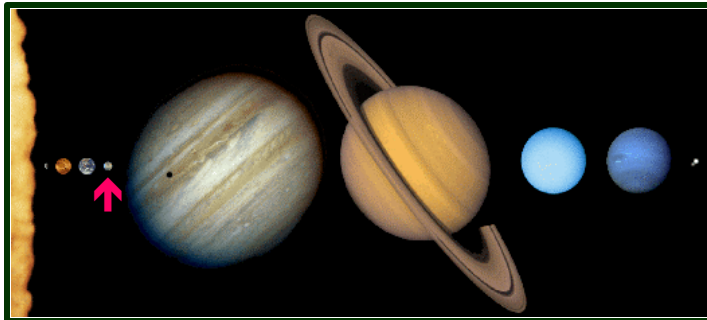
PATRICK J GANNON, PhD



EARTH OUR HOME SWEET HOME



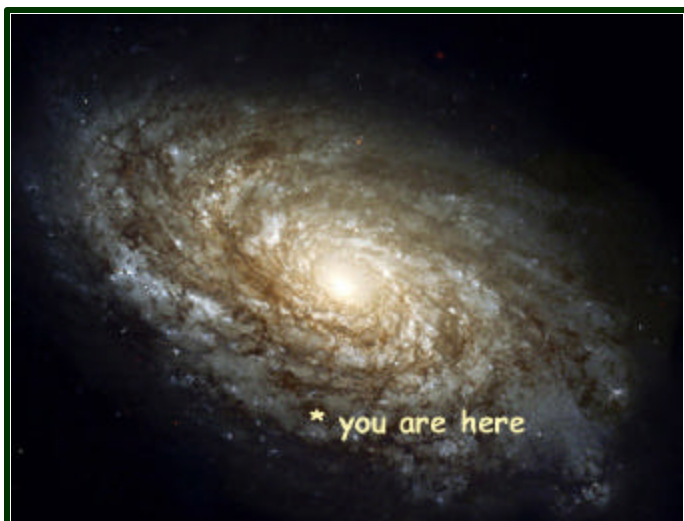
MOON'S EARTHRISE WE'VE BEEN HERE



SOLAR SYSTEM OUR LOCAL HOME IN SPACE



MARS WILL WE EVER GO THERE?



MILKY WAY - OUR BIG HOME IN SPACE



OUR UNIVERSE IS FULL OF GALAXIES

GOING FROM SEEDS TO STARS IN THE MILKY WAY GALAXY

LABORATORY EXERCISE

In a series of sequential, Hands-On / Inquiry-Based, exercises students will learn about:

- ❖ **SUBJECTIVE (instinctive) versus OBJECTIVE (impartial) QUANTIFICATION**
- ❖ **TRANSLATION Across units with Utilization of Linear, Area & Volume measures**
- ❖ **Quantitative prediction, followed by use of mathematics, to EXTEND from small to very large things**
- ❖ **Reasons for the difference between individuals in results of predictions**
- ❖ **Reasons for use of SCIENTIFIC NOTATION**
- ❖ **The power of these techniques used in our day to day life on Earth and by astronauts in Space**

AND NOW FOR SOME BIG TAKE-HOME MESSAGES

- **By utilization of OBJECTIVE QUANTIFICATION AND PREDICTIVE EXTENSION techniques, students will arrive at a powerful, eye-opening awareness of the enormous number of stars, like our Sun, in our Milky Way Galaxy**
- **To understand, with this concept in mind, just how MASSIVE our UNIVERSE really must be**
- **To bring it all back down to Earth and the reality of space travel:**
 - **We've been to the Moon**
 - **How much further could humans go IN SPACE? MAYBE TO OUR NEXT DOOR PLANET, **MARS**?**

❖ *Step-by-Step Student Exercises*

STEP 1 Students should write, in both **NUMERIC VALUE** and **SCIENTIFIC NOTATION**, the number of stars (**LIKE THE SUN OF OUR SOLAR SYTEM**) in the Milky Way Galaxy; **THAT IS:**

FOUR HUNDRED BILLION

(from) <http://casswww.ucsd.edu/public/tutorial/MW.html>

STEP 2 **STRICT** Time limit 2 minutes. Students **SUBJECTIVELY** (i.e., **INTUITIVELY**) **ESTIMATE** the number of seeds (GOYA whole yellow peas are cheap and a good star model) that would fill a 25-liter bucket (situated in classroom - empty) **BY EXTENSION** from what they see in a container filled with 25 ml of seeds

STEP 2.A. Students examine the seeds and get a "**FEEL**" or use an intuitive sense to estimate **SUBJECTIVELY**, the number of seeds that are contained within the 25ml vessel (like a detective, with poor evidence, may use intuition to get started on a case)

STEP 2.B. THEN, they use a scientific calculator to extend this subjective "**INTUITION-BASED**" estimated number from 25ml to 25 liters

STEP 2.C. THEN students **WRITE ON AN INDEX CARD**, their subjective estimate (in whole numbers and scientific notation) of the number of seeds that would occupy the 25 liter bucket

The student, that provided a **SUBJECTIVELY estimated value closest to the final **OBJECTIVELY** estimated value, (calculated in Steps 3 below), will be the:**

**INTUITIVE - THINKING BIG WINNER
SO
MOVE ON TO**

STEPS 3 & 4 TO FIND OUT THE ANSWER

STEP 3. Students (working individually or in groups of 2 or more to speed things up) empty the 25ml container of seeds into a tray

Then, use wooden coffee stir sticks, fingers or other device to count them. Those working in groups count separately and tally the final value

STEP 4. Calculate, by extension from the value for number of seeds counted in 25ml, an **OBJECTIVE (IMPARTIAL / DETACHED / SCIENTIFIC) ESTIMATE** of the number of seeds in 25 liters

WRITE THIS SECOND VALUE ON INDEX CARD USED BEFORE

ESTIMATE CARDS ARE SUBMITTED TO THE TEACHER

Teachers perform a mean and standard deviation exercise of both **SUBJECTIVE AND OBJECTIVE ESTIMATES** using calculator and chalkboard. Definition and explanation of these basic mathematical functions may be provided to the students

Values for SUBJECTIVE estimates are compared to the OBJECTIVE estimates

PROBABLE REASONS for differences (likely mostly in SD; i.e., considerable variation between intuitive skills in individuals) **ARE DISCUSSED**

METHODS & ANSWERS (for teachers)

STEP 1

Stars in Milky Way Galaxy

Four hundred billion

or

400,000,000,000

or

4.0×10^{11}

STEPS 2 & 3

Seed in 25 ml (subjective)

To be determined by class

Seed in 25 ml (objective)

100 (approximately)

STEP 4

Seeds in 25 liters (6.6 gallons)

are: 100 (= # of seeds in 25ml) \times 40 (= # of 25mls in 1 liter) \times 25 (= # of liters in bucket) = **ANSWER:**

in text format

One hundred thousand seeds

or, in numeric format

100,000 seeds

or, in scientific notation

1.0×10^5 seeds

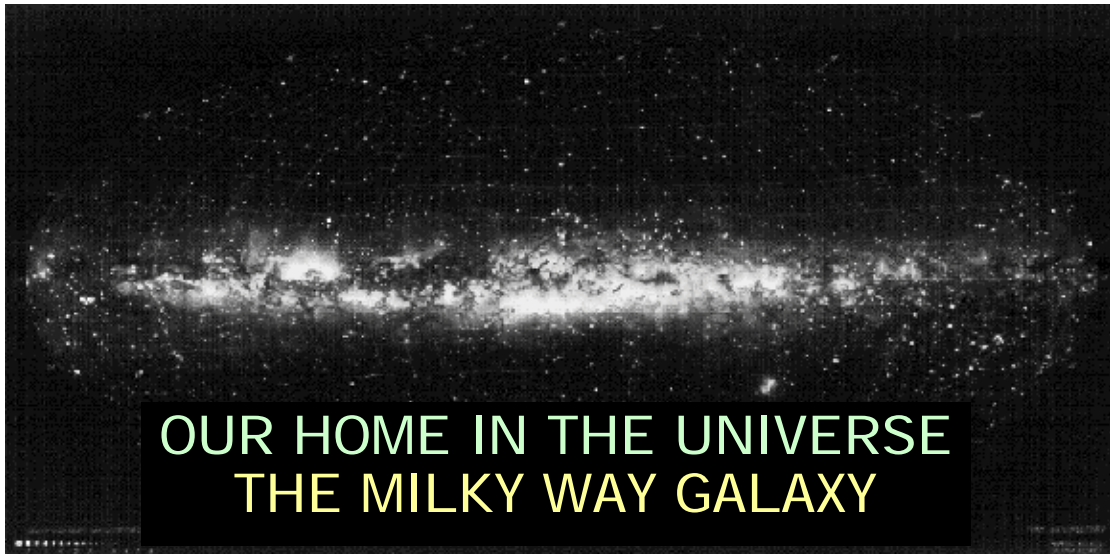
**Big number, BUT NOT EVEN CLOSE TO STARS IN OUR MILKY WAY GALAXY
= A SIX powers of ten difference**



Was it a lucky guess or an inspired estimate?

What method did the winner use to SUBJECTIVELY estimate the big number?

SEE BELOW FOR OPTIONAL EXTENSION QUESTIONS (E.Q.'s) / EXERCISES



E.Q. # 1 How many 25 liter buckets filled with seeds (where each seed represents a star), are needed to model the 400 billion stars in our Milky Way Galaxy

E.A. #1 Four million BUCKETS

or

4,000,000

or

4.0×10^6



E.Q. #2 How many football fields, that measure approximately 100 x 50 meters, would be filled by the 25 liter seed-filled buckets, which measure 30 cm diameter sitting side by side?

E.A. #2 72 FOOTBALL FIELDS...WOW (teachers see below for methods)

METHODS FOR TEACHERS

EQ#1 How many seed filled 25 liter buckets are needed to model the Milky Way?

a) Divide 400,000,000,000 (stars in MWG) by 100,000 (seeds in 25 liter bucket)

EQ#2 How many football fields, that measure approximately 100 x 50 meters, would be filled by the buckets, which measure 30 cm (or 3.0×10^1 cm) in diameter sitting side by side?

EQ2a Convert football field 50 x 100 meters to cm ($\times 100$) = 5,000 x 10,000 cm

EQ2b To get AREA OF FIELD, convert to square centimeters 5,000 x 10,000 = 50,000,000 cm^2 [= 5.0×10^7]

EQ2c Convert bucket footprint (how circular buckets sit side by side is a squared footprint; see diagram below) based on circular bucket radius of 30 x 30 cm, to square centimeters = **900 cm^2**

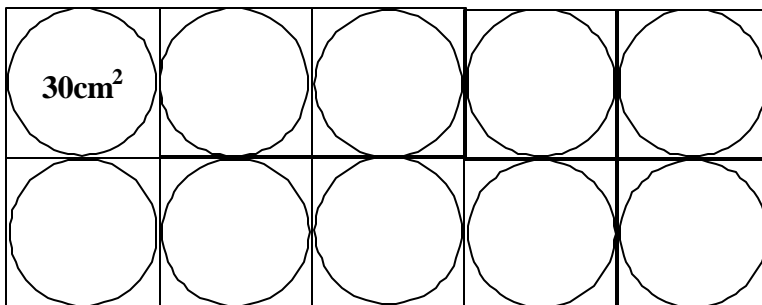


Diagram of circular buckets, and their squared "footprints" based on bucket's diameter. Buckets are aligned, with edges touching, when placed side by side. As such, dead spaces in between are mandated

EQ2d Divide 50,000,000 cm^2 (football field footprint) by 900 cm^2 (bucket footprint)

= 55,555 [5.6×10^4] to get # of buckets that would fill a football field (AN AREA-BASED ESTIMATE ONLY that does not allow for exact alignment

EQ2e Then, divide 55,555 (# of buckets that fill one football field) into # of seed filled buckets that emulate the Milky Way Galaxy (4,000,000 buckets) to estimate number of football fields occupied by seed-filled buckets

ANSWER = 72 football fields covered with seed-filled 25 liter buckets

