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EXERCISE

ING. LELIO CAMPANILE

FACTORIAL

the factorial of a positive integer n, denoted by $n!$, is the product of all positive integers less than or equal to n:

$$n! = n \times (n-1) \times (n-2) \times \ldots \times 3 \times 2 \times 1$$

$$n! = \prod_{i=1}^{n} i$$

RECURSION

method of solving a problem where the solution depends on solutions to smaller instances of the same problem

In python you could implement it with function that calls itself.

RECURSION

Whenever you write a recursive function, you need to include some kind of condition which will allow it to stop recursing

This happens when the function no longer calls itself so the function ends by returning a value (costant)

WRITE YOUR RECURSIVE FACTORIAL

EXPECTED RESULTS

N	N!
0	1
1	1
2	2
3	6
4	24
5	120
6	720
7	5040
8	40320

RECURSIVE FACTORIAL

```python
def factorial_rec(n):
    if n == 0:
        return 1
    else:
        return n * factorial_rec(n-1)
```

RECURSION

What would happen if we omitted that condition from our function?

In theory, the function would end up recursing forever and never terminate, but in practice the program will crash with a RuntimeError

RECURSION

Writing fail-safe recursive functions is difficult

Any recursive function can be re-written in an iterative way which avoids recursion

ITERATIVE FACTORIAL

```
def factorial(n):
    for i in range((n-1), 0, -1):
        n = n * i
    return n
```

FIBONACCI NUMBERS

the Fibonacci numbers, commonly denoted Fn form a sequence, called the Fibonacci sequence, such that each number is the sum of the two preceding ones, starting from 0 and 1:

$F_0 = 0, F_1 = 1$ and

$$F_n = F_{n-1} + F_{n-2}$$

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55

RECURSIVE FIBONACCI

```
def fibonacci_rec (n):
  if n < 2:
    return n
  else:
    return fibonacci_rec(n-1) + fibonacci_rec(n-2)
```

ITERATIVE FIBONACCI

```
def fibonacci(n):
    if n == 0:
        return n
    last = 0
    next = 1
    for _ in range(1,n):
        previous_last = last
        last = next
        next = previous_last + last
    return next
```

PIGRECO - LEIBNIZ FORMULA

$$\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots + \frac{(-1)^n}{2n+1} + \cdots = \frac{\pi}{4}.$$

SIMPLIFIED VERSION TO CALCULATE THE CONVERGENCE OF π

$$\pi = 4/1 - 4/3 + 4/5 - 4/7 + 4/9 - 4/11....$$

```python
def calculate_pi(n_terms):
    numerator= 4.0
    denominator = 1.0
    operation = 1.0
    pi = 0.0
    for _ in range(n_terms):
        pi += operation * (numerator/denominator)
        denominator += 2.0
        operation *= -1.0
    return pi
```

SEARCHING

LINEAR SEARCH

```python
def linear_contains(iterable, key):
    for item in iterable:
        if item == key:
            return True
    return False
```

BINARY SEARCH

ONLY ON SORTED DATA

```
def binary_contains(sorted_iterable, key):
    low = 0
    high = len(sorted_iterable) - 1
    while low <= high:
        mid = (low + high) // 2
        if sorted_iterable[mid] < key:
            low = mid + 1
        elif sorted_iterable[mid] > key:
            high = mid - 1
        else:
            return True
    return False
```

CONTACTS

```python
if __name__=="__main__":

    print('Contacts')
    print('------------------------------')
    contacts={}
    your_choice= 0
    while your_choice != 5:
        menu()
        your_choice=int(input('Select your option: '))
        print('------------------------------')
        if your_choice==1:
            add_contact(contacts)
        elif your_choice==2:
            remove_contact(contacts)
        elif your_choice==3:
            list_contacts(contacts)
        elif your_choice==4:
            search_contact(contacts)
```

```python
def menu():
    print('1 - add a contact')
    print('2 - remove a contact')
    print('3 - list all contacts')
    print('4 - search a contact')
    print('5 - exit')
```

```python
def add_contact(dict):
    contact=input('Insert name: ')
    mobile_number=input('Mobile number: ')
    dict[contact]=mobile_number
    print('Contact %s with %s number added\n' % (contact,mobile_number))
```

```python
def remove_contact(dict):
    contact = input('Contact to remove: ')
    if contact in dict.keys():
        del dict[contact]
        print('Contact removed')
    else:
        print('Contact %s not found' % (contact))
```

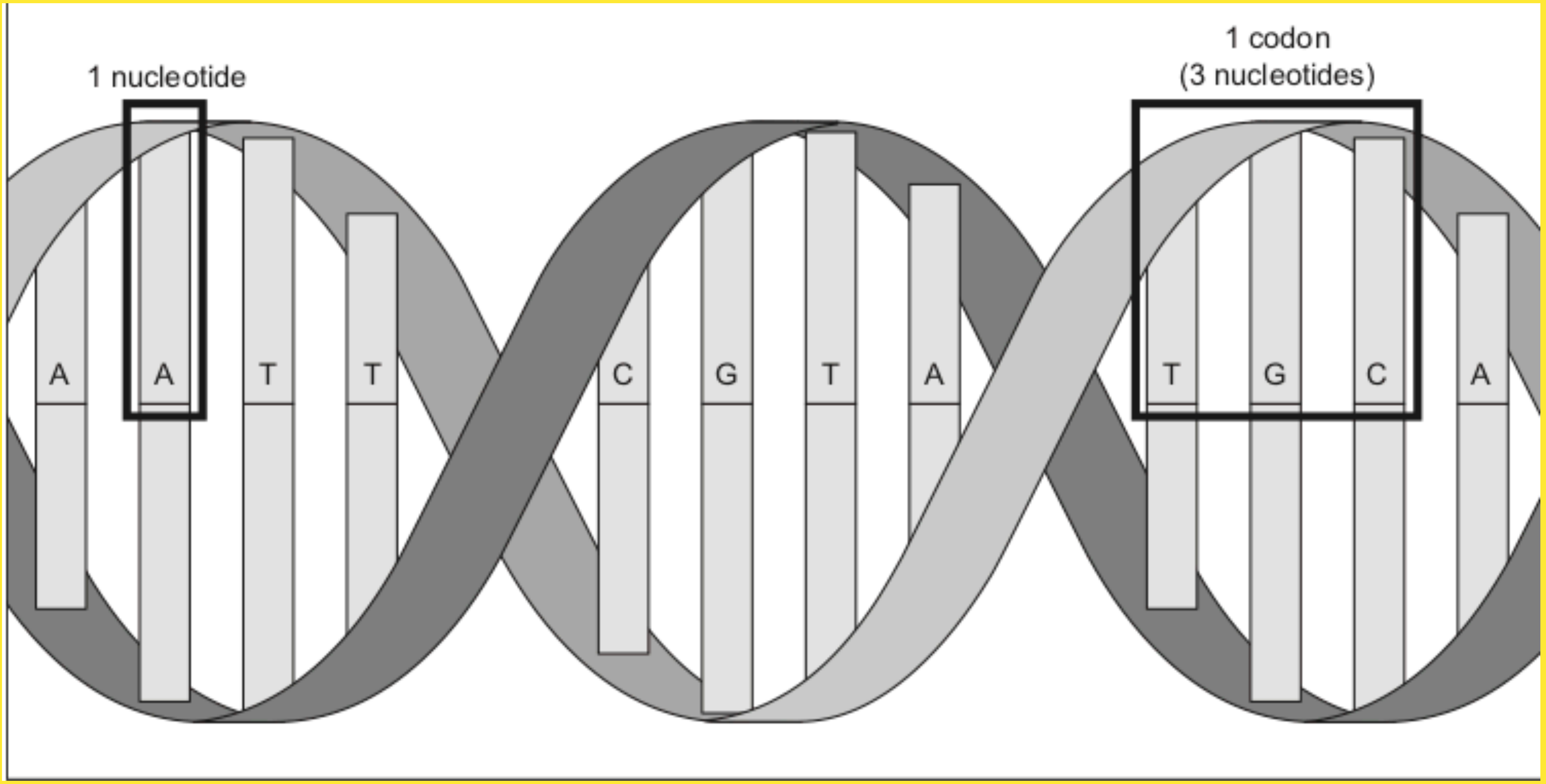
```
def list_contacts(dict):
    if len(dict)==0:
        print("Nothing here")
    for x in dict.keys():
        print("Contats: %s \tNumber: %s" % (x, dict[x]))
```

```python
def search_contact(dict):
    contact = input('Insert contact to search: ')
    for name in dict.keys():
        if name == contact:
            print('Contact %s with %s number\n' % (name,dict[name]))
    print("Nothing here")
```

DNA

DEOXYRIBONUCLEIC ACID

Genes are commonly represented in computer software as a sequence of the characters cytosine [C], guanine [G], adenine [A] or thymine [T]. Each letter represents a nucleotide, and the combination of three nucleotides is called a codon.


1 nucleotide
1 codon
(3 nucleotides)
A
A
T
T
C
G
T
A
T
G
C
A

```python
Nucleotide = {'A': 'A', 'C':'C', 'G':'G', 'T':'T'}
gene_str = "ACGTGGCTCTCTAACGTACGTACGTACGGGGTTTATATATACCCTAGGACTCCCTTT"


def string_to_gene(s):
    gene = []
    for i in range(0, len(s), 3):
        if (i + 2) >= len(s):
            return gene
        codon = (Nucleotide[s[i]], Nucleotide[s[i+1]], Nucleotide[s[i+2]])
        gene.append(codon)
    return gene
```

```python
def linear_contains (gene, key_codon):
    for codon in gene:
        if codon == key_codon: # only for educational purpose
        #else return (key_codon in gene) should be enough
            return True
    return False
```

BINARY SEARCH WORKS ONLY ON SORTED GENE!

```
def binary_contains(gene, key_codon):
    low = 0
    high = len(gene) - 1
    while low <= high:
        mid = (low + high) // 2
        if gene[mid] < key_codon:
            low = mid + 1
        elif gene[mid] > key_codon:
            high = mid - 1
        else:
            return True
    return False
```

```python
if __name__ == '__main__':
    gene_str = "ACGTGGCTCTCTAACGTACGTACGTACGGGGTTTATATATACCCTAGGACTCCCTTT"
    my_gene = string_to_gene(gene_str)
    print(my_gene)
    acg = (Nucleotide['A'], Nucleotide['C'], Nucleotide['G'])
    gat = (Nucleotide['G'], Nucleotide['A'], Nucleotide['T'])

    print(linear_contains(my_gene, acg))  # True
    print(linear_contains(my_gene, gat))  # False

    sorted_gene = sorted(my_gene)
    print(binary_contains(sorted_gene, acg)) # True
    print(binary_contains(sorted_gene, gat)) # False
```