```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import warnings
import matplotlib.patches as mpatches
import matplotlib.lines as mlines
from matplotlib.patches import FancyBboxPatch, FancyArrowPatch
import matplotlib.gridspec as gridspec
warnings.filterwarnings('ignore')
```

```
!wget -q --show-progress -O food_facts.csv.gz \
  "https://static.openfoodfacts.org/data/en.openfoodfacts.org.produ

print("Download complete")
```

```
food_facts.csv.gz   100%[===================>]   1.14G  32.8MB/s
Download complete
```

```
# The full dataset has 180+ columns. We only need these 8.
COLUMNS_NEEDED = [
    'product_name',
    'categories_tags',
    'ingredients_text',
    'energy_100g',
    'sugars_100g',
    'proteins_100g',
    'fat_100g',
    'fiber_100g',
]

print(f"Loaded {len(COLUMNS_NEEDED)} columns out of 180+")
```

```
Loaded 8 columns out of 180+
```

```
df_raw = pd.read_csv(
    'food_facts.csv.gz',
    sep='\t',
    nrows=500_000,
    usecols=COLUMNS_NEEDED,
    low_memory=False,
    on_bad_lines='skip'
)

print(f"Loaded {len(df_raw):,} rows ")
print(f"Shape: {df_raw.shape}")
df_raw.tail(5)
```

```
Loaded 500,000 rows
Shape: (500000, 8)
```

	product_name	categories_tags	ingredients_text	energ
499995	Orange Juice	NaN	orange juice	
499996	Orange Juice Medium Pulp	NaN	NaN	
499997	Black sweet tea	en:plant-based-foods-and-beverages,en:beverage...	NaN	
499998	Homestyle Lemonade	NaN	NaN	
499999	Large Grade A Vegetarian Fed Cage Free Eggs	en:farming-products,en:eggs,en:chicken-eggs,en...	NaN	

```
# Data Exploration

print(" DATASET OVERVIEW \n")
print(f"Total rows: {len(df_raw):,}")
print(f"Total columns: {df_raw.shape[1]}")
print("\n NULL VALUE COUNT (per column) ")
print(df_raw.isnull().sum())
print("\n DATA TYPES ")
print(df_raw.dtypes)
print("\n BASIC STATISTICS (numeric columns) ")
df_raw[['sugars_100g', 'proteins_100g', 'fat_100g', 'fiber_100g']].
```

```
 DATASET OVERVIEW

Total rows: 500,000
```

```
Total columns: 8

 NULL VALUE COUNT (per column)
product_name         15579
categories_tags     229747
ingredients_text    231191
energy_100g          74707
fat_100g             77345
sugars_100g          93436
fiber_100g          177542
proteins_100g        76871
dtype: int64

 DATA TYPES
product_name         object
categories_tags      object
ingredients_text     object
energy_100g         float64
fat_100g            float64
sugars_100g         float64
fiber_100g          float64
proteins_100g       float64
dtype: object

 BASIC STATISTICS (numeric columns)
```

	sugars_100g	proteins_100g	fat_100g	fiber_100g
count	406564.000000	423129.000000	422655.000000	322458.000000
mean	17.542264	8.657712	14.869983	3.252585
std	43.720976	23.888684	41.107267	25.655246
min	-1.450000	-12.600000	0.000000	-44.700000
25%	1.000000	0.770000	0.000000	0.000000
50%	5.000000	5.000000	5.260000	1.400000
75%	22.200000	10.800000	20.000000	3.571429
max	11111.000000	7270.000000	11111.000000	11800.000000

```
df_clean = df_raw.dropna(subset=['product_name', 'sugars_100g', 'pr

rows_dropped = len(df_raw) - len(df_clean)
print(f"Rows before cleaning: {len(df_raw):,}")
print(f"Rows dropped (missing critical values): {rows_dropped:,}")
print(f"Rows remaining: {len(df_clean):,}")
```

```
Rows before cleaning: 500,000
Rows dropped (missing critical values): 98,913
Rows remaining: 401,087
```

```
# Define valid ranges
VALID_MIN = 0
VALID_MAX = 100

df_clean = df_clean[
    (df_clean['sugars_100g']   >= VALID_MIN) & (df_clean['sugars_10
    (df_clean['proteins_100g'] >= VALID_MIN) & (df_clean['proteins_
    (df_clean['fat_100g'].isna() | ((df_clean['fat_100g'] >= VALID_
    (df_clean['fiber_100g'].isna() | ((df_clean['fiber_100g'] >= VA
]

print(f"Rows after removing impossible values: {len(df_clean):,}")
```

```
Rows after removing impossible values: 391,528
```

```
# clean data

print(" CLEAN DATASET STATS \n")
print(df_clean[['sugars_100g', 'proteins_100g', 'fat_100g', 'fiber_

print("\n SAMPLE PRODUCTS ")
print(df_clean[['product_name', 'sugars_100g', 'proteins_100g']].sa

df_clean.to_csv('food_facts_clean.csv', index=False)
print("\nClean dataset saved as food_facts_clean.csv")
print(f"Final shape: {df_clean.shape}")
```

```
 CLEAN DATASET STATS

       sugars_100g  proteins_100g   fat_100g  fiber_100g
count    391528.00      391528.00  390603.00   307274.00
mean         14.79           7.72      11.93        2.83
std          20.52           9.84      16.07        5.17
min           0.00           0.00       0.00        0.00
25%           1.10           0.83       0.00        0.00
50%           5.00           4.93       5.00        1.40
75%          21.25          10.53      18.75        3.57
max         100.00         100.00     100.00      100.00

 SAMPLE PRODUCTS
                                        product_name  sugars_100g  pro
316270                          Breaded squid rings     1.000000
130944  100% Whole Grain Rolled Oats Old Fashioned     1.000000
264987                               Grape seed oil     0.000000
20828                          Maple Syrup Sachet    66.700000
449521                 Taro Cake with Dried Shrimp     1.330000
389545                           MESQUITE BARBECUE     7.142857
120966                    Buttermilk Fudge Stripes     9.000000
457890                             Energy Drink Mix     0.000000
457709                              Cut Green Beans     0.830000
441208                    Cookie dough snack-pack    37.500000

Clean dataset saved as food_facts_clean.csv
Final shape: (391528, 8)
```

```
print(" SAMPLE OF RAW categories_tags VALUES \n")

# Show 100 examples
sample_tags = df_clean['categories_tags'].dropna().sample(100, rand
for tag in sample_tags:
    print(tag)
    print("---")
```

```
---
```

```
en:snacks,en:sweet-snacks,en:confectioneries,en:candies,en:gummi-c
---
en:snacks
---
en:plant-based-foods-and-beverages,en:plant-based-foods,en:cereals
---
en:condiments,en:sauces,en:dips
---
en:desserts
---
en:condiments,en:sauces
---
en:plant-based-foods-and-beverages,en:beverages,en:plant-based-bev
---
en:dairies,en:fermented-foods,en:fermented-milk-products,en:desser
---
en:syrups
---
en:undefined
---
en:condiments,en:sauces,en:groceries
---
en:undefined
---
en:plant-based-foods-and-beverages,en:dairy-substitutes,en:milk-su
---
en:snacks,en:sweet-snacks,en:biscuits-and-cakes,en:cakes
---
en:condiments,en:sauces,en:groceries
---
en:plant-based-foods-and-beverages,en:plant-based-foods,en:cereals
---
en:snacks,en:sweet-snacks,en:biscuits-and-cakes,en:pastries
---
en:beverages-and-beverages-preparations,en:beverages,en:carbonated
---
en:undefined
---
en:meats-and-their-products,en:meats,en:chicken-and-its-products,e
---
en:dairies,en:fermented-foods,en:fermented-milk-products,en:desser
---
en:desserts,en:frozen-foods,en:frozen-desserts,en:ice-creams-and-s
---
en:snacks,en:sweet-snacks,en:biscuits-and-cakes
---
en:plant-based-foods-and-beverages,en:plant-based-foods,en:legumes
---
en:beverages,en:carbonated-drinks,en:sodas,en:sweetened-beverages
---
en:snacks,en:sweet-snacks,en:biscuits-and-cakes,en:pastries
---
en:meals,en:rice-dishes
```

```
---
en:dairies,en:milks
---
```

```
# Step 1: Define what to EXCLUDE first
EXCLUDE_PATTERNS = [
    'beverage',
    'juice',
    'soda',
    'milk',
    'cream',
    'ice-cream',
    'frozen-dessert',
    'frozen-food',
    'mochi-ice',
    'sorbet',
    'soup',
    'sauce',
    'condiment',
    'pasta',
    'rice-dish',
    'meal',
    'bread',
    'cereal',
    'muesli',
    'supplement',
    'syrup',
    'honey',
    'spread',
    'pizza',
    'meat',
    'chicken',
    'vegetable',
    'tomato',
    'legume',
    'canned-bean',
]

# Step 2: Define SNACK category mapping (priority ordered — first m
CATEGORY_MAP = [
    # Protein / Fitness Bars — most specific, highest priority
    ('protein-bar',             'Protein & Fitness Bars'),
    ('energy-bar',              'Protein & Fitness Bars'),
    ('cereal-bar',              'Protein & Fitness Bars'),
    ('granola-bar',             'Protein & Fitness Bars'),
    ('nutrition-bar',           'Protein & Fitness Bars'),
```

```
    ('sport',                   'Protein & Fitness Bars'),

    # Chips & Savory Snacks
    ('chips-and-fries',         'Chips & Savory Snacks'),
    ('potato-crisp',            'Chips & Savory Snacks'),
    ('crisps',                  'Chips & Savory Snacks'),
    ('bbq-chip',                'Chips & Savory Snacks'),
    ('chip',                    'Chips & Savory Snacks'),
    ('pretzel',                 'Chips & Savory Snacks'),
    ('popcorn',                 'Chips & Savory Snacks'),
    ('puffed',                  'Chips & Savory Snacks'),
    ('salty-snack',             'Chips & Savory Snacks'),
    ('salted-snack',            'Chips & Savory Snacks'),
    ('savory-snack',            'Chips & Savory Snacks'),
    ('crackers-appetizer',      'Chips & Savory Snacks'),
    ('cracker',                 'Chips & Savory Snacks'),

    # Cookies & Biscuits
    ('biscuits-and-cakes',      'Cookies & Biscuits'),
    ('biscuit',                 'Cookies & Biscuits'),
    ('cookie',                  'Cookies & Biscuits'),
    ('wafer',                   'Cookies & Biscuits'),
    ('brownie',                 'Cookies & Biscuits'),
    ('toaster-pastri',          'Cookies & Biscuits'),
    ('pastri',                  'Cookies & Biscuits'),

    # Candy & Confectionery
    ('confectioner',            'Candy & Confectionery'),
    ('candies',                 'Candy & Confectionery'),
    ('candy',                   'Candy & Confectionery'),
    ('gummi',                   'Candy & Confectionery'),
    ('gummy',                   'Candy & Confectionery'),
    ('jelly-bean',              'Candy & Confectionery'),
    ('lollipop',                'Candy & Confectionery'),
    ('caramel',                 'Candy & Confectionery'),
    ('chocolate',               'Candy & Confectionery'),
    ('sweet-snack',             'Candy & Confectionery'),

    # Nuts & Seeds
    ('roasted-nut',             'Nuts & Seeds'),
    ('roasted-peanut',          'Nuts & Seeds'),
    ('trail-mix',               'Nuts & Seeds'),
    ('nut',                     'Nuts & Seeds'),
    ('seed',                    'Nuts & Seeds'),
    ('almond',                  'Nuts & Seeds'),
    ('peanut',                  'Nuts & Seeds'),
    ('cashew',                  'Nuts & Seeds'),
```

```
    # Dairy Snacks
    ('yogurt',                  'Dairy & Yogurt Snacks'),
    ('yoghurt',                 'Dairy & Yogurt Snacks'),
    ('cheese-snack',            'Dairy & Yogurt Snacks'),
    ('dairy-snack',             'Dairy & Yogurt Snacks'),

    # Fruit & Vegetable Snacks (room temp only — dried/packaged)
    ('dried-fruit',             'Fruit & Veg Snacks'),
    ('fruit-snack',             'Fruit & Veg Snacks'),
    ('fruit-bar',               'Fruit & Veg Snacks'),
    ('fruit-based-food',        'Fruit & Veg Snacks'),
    ('fruits-based-food',       'Fruit & Veg Snacks'),
    ('vegetable-chip',          'Fruit & Veg Snacks'),
    ('dried-vegetable',         'Fruit & Veg Snacks'),

    # General Snacks — broad catch-all, always last
    ('snack',                   'General Snacks'),
]

print(f" Exclusion patterns defined: {len(EXCLUDE_PATTERNS)}")
print(f" Category rules defined: {len(CATEGORY_MAP)}")
print(f" Covering {len(set(v for _, v in CATEGORY_MAP))} unique cat
```

```
 Exclusion patterns defined: 30
 Category rules defined: 56
 Covering 8 unique categories
```

```
def assign_category(tags_string):
    """
    Takes a raw tags string, returns a clean category label or None

    Logic:
    1. Null/undefined tags → None (skip)
    2. Matches an exclusion pattern → None (not a snack)
    3. Matches a category keyword → return that category
    4. No match → None (uncategorized, skip)
    """

    # Guard: null values
    if pd.isna(tags_string):
        return None

    tags_lower = tags_string.lower()

    # Guard: garbage tags like en:null, en:undefined
    if tags_lower.strip() in ('en:null', 'en:undefined', 'en:null,'
        return None
```

```
    # Step 1: Check exclusions FIRST
    # If this product matches any exclusion pattern, it's not a sna
    for exclude in EXCLUDE_PATTERNS:
        if exclude in tags_lower:
            # Special case: "vegetable-chip" should NOT be excluded
            # even though it contains "vegetable"
            if exclude == 'vegetable' and 'vegetable-chip' in tags_
                continue
            return None

    # Step 2: Match to a snack category
    for keyword, category in CATEGORY_MAP:
        if keyword in tags_lower:
            return category

    return None


# Test with real examples from your actual data
test_cases = [
    ("Mochi ice cream",     "en:desserts,en:frozen-foods,en:frozen-
    ("Potato crisps",       "en:snacks,en:salty-snacks,en:chips-and
    ("Peanuts",             "en:legumes-and-their-products,en:nuts,
    ("Gummi candies",       "en:snacks,en:sweet-snacks,en:confectio
    ("Biscuits",            "en:snacks,en:sweet-snacks,en:biscuits-
    ("Orange juice",        "en:beverages,en:fruit-juices,en:orange
    ("Toaster pastries",    "en:snacks,en:sweet-snacks,en:biscuits-
    ("en:null tag",         "en:null"),
    ("Soda",                "en:beverages,en:carbonated-drinks,en:s
    ("BBQ chips",           "en:bbq-chips"),
    ("Crackers",            "en:snacks,en:salty-snacks,en:biscuits-
    ("Vegetable chips",     "en:snacks,en:salty-snacks,en:vegetable
]

print("=== CLASSIFICATION TEST (with real tag patterns) ===\n")
for name, tags in test_cases:
    result = assign_category(tags)
    status = "added" if result else " (excluded)"
    print(f"{status}  {name:<20} → {result}")
```

```
=== CLASSIFICATION TEST (with real tag patterns) ===

 (excluded)  Mochi ice cream      → None
added  Potato crisps        → Chips & Savory Snacks
 (excluded)  Peanuts             → None
added  Gummi candies        → Candy & Confectionery
added  Biscuits             → Cookies & Biscuits
 (excluded)  Orange juice        → None
added  Toaster pastries     → Cookies & Biscuits
```

```
 (excluded)  en:null tag          → None
 (excluded)  Soda                 → None
added  BBQ chips            → Chips & Savory Snacks
added  Crackers             → Chips & Savory Snacks
added  Vegetable chips      → Chips & Savory Snacks
```

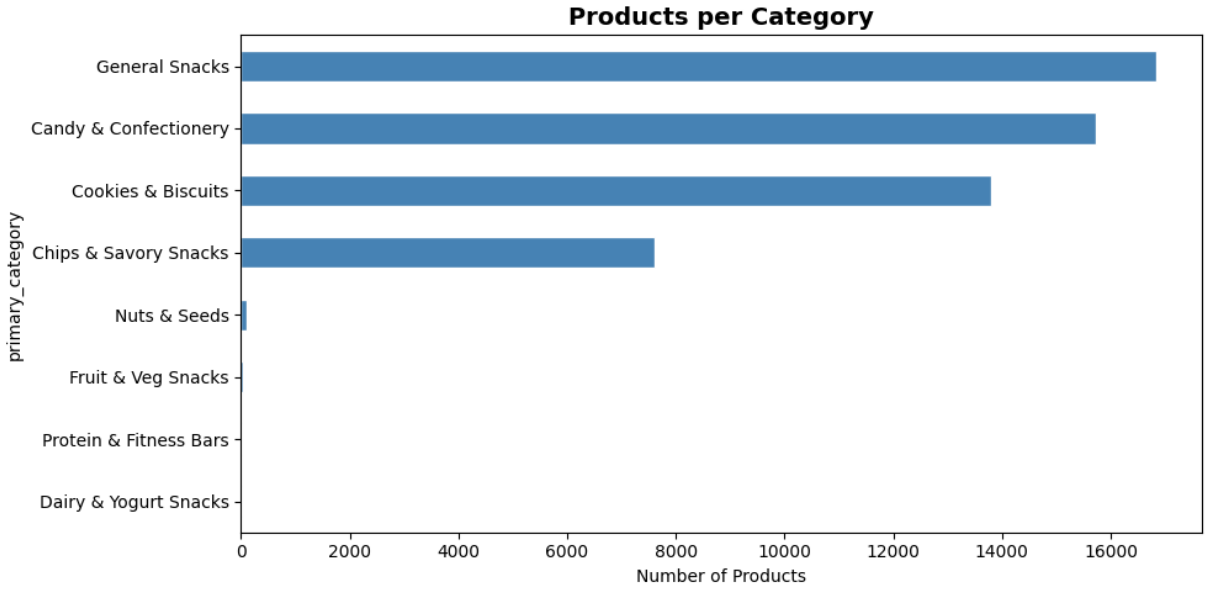
```
# This creates a new column called 'primary_category'
df_clean['primary_category'] = df_clean['categories_tags'].apply(as

#  filter OUT rows where primary_category is None

df_snacks = df_clean[df_clean['primary_category'].notna()].copy()

print(f"\nTotal rows before snack filter: {len(df_clean):,}")
print(f"Snack products identified:      {len(df_snacks):,}")
print(f"Non-snack rows removed:         {len(df_clean) - len(df_sna
```

```

Total rows before snack filter: 391,528
Snack products identified:      54,169
Non-snack rows removed:         337,359
```

```
category_counts = df_snacks['primary_category'].value_counts()

print(" CATEGORY DISTRIBUTION \n")
print(category_counts.to_string())
print(f"\nTotal snack products: {len(df_snacks):,}")

# Visualize it
import matplotlib.pyplot as plt

fig, ax = plt.subplots(figsize=(10, 5))
category_counts.plot(kind='barh', ax=ax, color='steelblue', edgecol
ax.set_xlabel('Number of Products')
ax.set_title('Products per Category', fontsize=14, fontweight='bold
ax.invert_yaxis()
plt.tight_layout()
plt.savefig('category_distribution.png', dpi=150, bbox_inches='tigh
plt.show()
print("Chart saved")
```

```
 CATEGORY DISTRIBUTION

primary_category
General Snacks           16835
Candy & Confectionery    15717
Cookies & Biscuits       13810
Chips & Savory Snacks     7620
Nuts & Seeds               105
```

```
Fruit & Veg Snacks           38
Protein & Fitness Bars       24
Dairy & Yogurt Snacks        20

Total snack products: 54,169
```




```
Chart saved
```

```
summary = df_snacks.groupby('primary_category').agg(
    product_count   = ('product_name',  'count'),
    avg_sugar       = ('sugars_100g',   'mean'),
    avg_protein     = ('proteins_100g', 'mean'),
    avg_fat         = ('fat_100g',      'mean'),
    median_sugar    = ('sugars_100g',   'median'),
    median_protein  = ('proteins_100g', 'median'),
).round(2).sort_values('avg_sugar', ascending=False)

print(" NUTRITIONAL PROFILE BY CATEGORY \n")
print(summary.to_string())

# Save  snack dataset
df_snacks.to_csv('food_facts_snacks.csv', index=False)
print("\n Snack dataset saved as food_facts_snacks.csv")
```

```
 NUTRITIONAL PROFILE BY CATEGORY

                        product_count  avg_sugar  avg_protein  avg_f
primary_category
Candy & Confectionery           15717      54.00         3.37    12.
Fruit & Veg Snacks                 38      51.72         3.62     3.
Cookies & Biscuits              13810      29.06         5.28    16.
Nuts & Seeds                      105      19.08        10.36    27.
General Snacks                  16835      17.54        10.70    26.
Dairy & Yogurt Snacks              20      15.63         8.83    10.
Chips & Savory Snacks            7620       8.23         5.15    14.
Protein & Fitness Bars             24       4.24         0.47     0.

 Snack dataset saved as food_facts_snacks.csv
```

Data Visualization

```
plt.rcParams.update({
    'figure.facecolor':     'white',
    'axes.facecolor':       '#F8F9FA',
    'axes.grid':            True,
    'grid.color':           '#E0E0E0',
    'grid.linewidth':       0.7,
    'grid.alpha':           0.8,
    'axes.spines.top':      False,
    'axes.spines.right':    False,
    'axes.spines.left':     True,
    'axes.spines.bottom':   True,
    'axes.labelsize':       12,
    'axes.titlesize':       14,
    'axes.titleweight':     'bold',
    'xtick.labelsize':      10,
    'ytick.labelsize':      10,
    'legend.fontsize':      10,
    'legend.framealpha':    0.9,
    'font.family':          'sans-serif',
})

CATEGORY_COLORS = {
    'Candy & Confectionery':    '#E63946',
    'Cookies & Biscuits':       '#F4A261',
    'Chips & Savory Snacks':    '#E9C46A',
    'General Snacks':           '#A8DADC',
    'Fruit & Veg Snacks':       '#52B788',
    'Nuts & Seeds':             '#2D6A4F',
    'Dairy & Yogurt Snacks':    '#457B9D',
    'Protein & Fitness Bars':   '#1D3557',
}
```

```
try:
    df_snacks
    print(f"df_snacks in memory: {len(df_snacks):,} rows")
except NameError:
    df_snacks = pd.read_csv('food_facts_snacks.csv')
    print(f"Reloaded: {len(df_snacks):,} rows")

# Cap at 99th percentile for visual clarity — all data still in df_
# We only cap for PLOTTING, not for stats
p99_sugar   = df_snacks['sugars_100g'].quantile(0.99)
p99_protein = df_snacks['proteins_100g'].quantile(0.99)

df_plot = df_snacks[
    (df_snacks['sugars_100g']   <= p99_sugar) &
    (df_snacks['proteins_100g'] <= p99_protein)
].copy()

print(f"Rows available for plotting: {len(df_plot):,}")
print(f"(99th pct: sugar={p99_sugar:.1f}g, protein={p99_protein:.1f
```

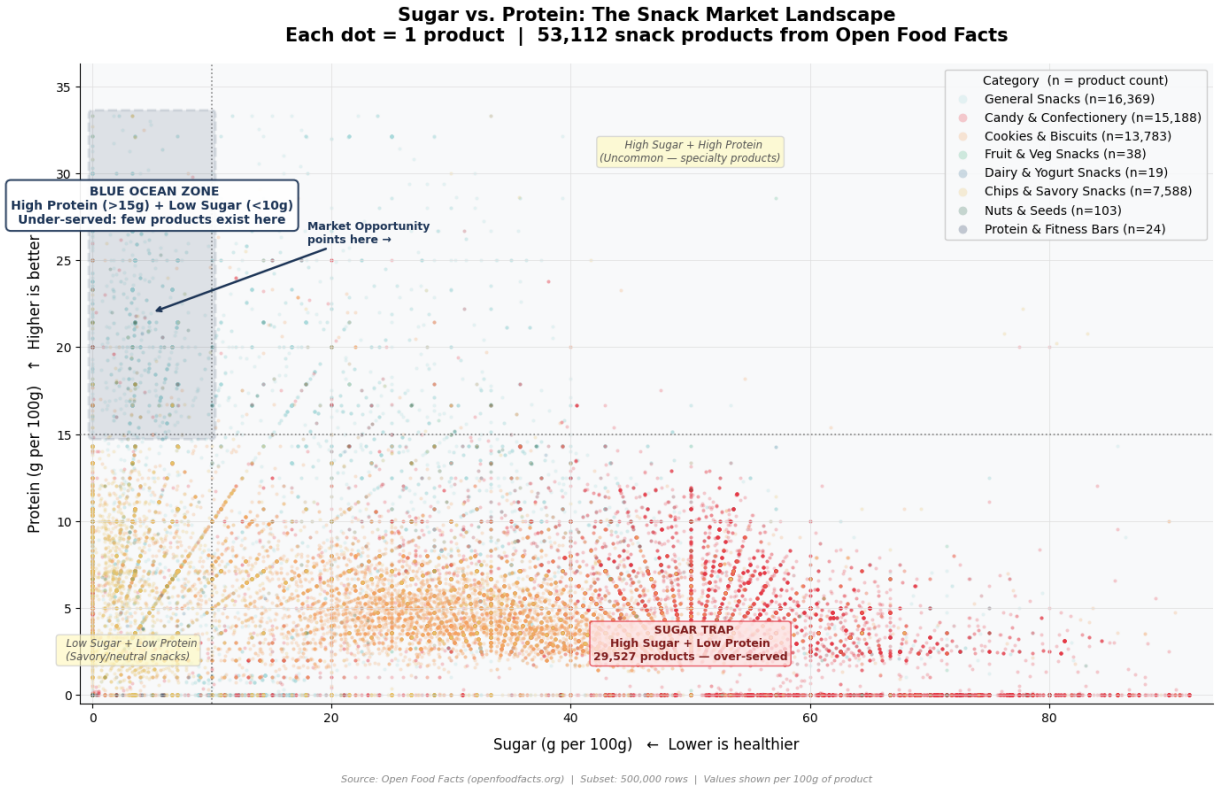
```
df_snacks in memory: 54,169 rows
Rows available for plotting: 53,112
(99th pct: sugar=91.7g, protein=33.3g)
```

```
fig, ax = plt.subplots(figsize=(14, 9))

PLOT_ORDER = [
    'General Snacks',
    'Candy & Confectionery',
    'Cookies & Biscuits',
    'Fruit & Veg Snacks',
    'Dairy & Yogurt Snacks',
    'Chips & Savory Snacks',
    'Nuts & Seeds',
    'Protein & Fitness Bars',
]

for category in PLOT_ORDER:
    subset = df_plot[df_plot['primary_category'] == category]
    ax.scatter(
        subset['sugars_100g'],
        subset['proteins_100g'],
        c=CATEGORY_COLORS[category],
        label=f"{category} (n={len(subset):,})",
        alpha=0.25,
        s=8,
        linewidths=0,
```

```
            rasterized=True,
        )

    #  Blue Ocean Zone rectangle
    blue_ocean_rect = FancyBboxPatch(
        (0, 15),
        10, p99_protein - 15,
        boxstyle="round,pad=0.3",
        facecolor='#1D3557',
        edgecolor='#1D3557',
        alpha=0.12,
        linewidth=2,
        linestyle='--',
        zorder=5
    )
    ax.add_patch(blue_ocean_rect)

    # Blue Ocean label inside the box
    ax.text(
        5, p99_protein * 0.88,          \
        ' BLUE OCEAN ZONE\n'
        'High Protein (>15g) + Low Sugar (<10g)\n'
        'Under-served: few products exist here',
        fontsize=10,
        fontweight='bold',
        color='#1D3557',
        ha='center',
        va='top',
        zorder=6,
        bbox=dict(
            boxstyle='round,pad=0.4',
            facecolor='white',
            edgecolor='#1D3557',
            alpha=0.92,
            linewidth=1.5
        )
    )

    # Quadrant divider lines
    ax.axhline(y=15, color='#555555', linewidth=1.2, linestyle=':', alp
    ax.axvline(x=10, color='#555555', linewidth=1.2, linestyle=':', alp

    # Quadrant labels in the three "non-blue-ocean" corners
    ax.text(50, p99_protein * 0.92,
            '  High Sugar + High Protein\n(Uncommon — specialty product
            fontsize=8.5, color='#555', ha='center', style='italic',
            bbox=dict(boxstyle='round', facecolor='#FFF9C4', alpha=0.7,
```

```
    ax.text(50, 2,
            '  SUGAR TRAP\n'
            'High Sugar + Low Protein\n'
            '29,527 products — over-served',
            fontsize=9, color='#7f1d1d', ha='center', fontweight='bold'
            bbox=dict(boxstyle='round', facecolor='#FEE2E2', alpha=0.8,

    ax.text(3, 2,
            '  Low Sugar + Low Protein\n(Savory/neutral snacks)',
            fontsize=8.5, color='#555', ha='center', style='italic',
            bbox=dict(boxstyle='round', facecolor='#FFF9C4', alpha=0.7,

    #  Arrow pointing to the opportunity
    ax.annotate(
        'Market Opportunity\npoints here →',
        xy=(5, 22),
        xytext=(18, 26),
        fontsize=9,
        color='#1D3557',
        fontweight='bold',
        arrowprops=dict(
            arrowstyle='->', color='#1D3557', lw=1.8
        )
    )

    #  Titles and labels
    ax.set_title(
        'Sugar vs. Protein: The Snack Market Landscape\n'
        'Each dot = 1 product  |  53,112 snack products from Open Food
        fontsize=15,
        fontweight='bold',
        pad=18
    )
    ax.set_xlabel('Sugar (g per 100g)   ←  Lower is healthier', fontsiz
    ax.set_ylabel('Protein (g per 100g)   ↑  Higher is better', fontsiz

    #  Axis limits with breathing room
    ax.set_xlim(-1, p99_sugar + 2)
    ax.set_ylim(-0.5, p99_protein + 3)

    #  Legend — sorted, with product counts
    handles, labels = ax.get_legend_handles_labels()
    ax.legend(
        handles, labels,
        title='Category  (n = product count)',
        title_fontsize=10,
        loc='upper right',
        framealpha=0.95,
```

```
    edgecolor='#cccccc',
    markerscale=2.5
)

#  Footer annotation
fig.text(
    0.5, 0.01,
    'Source: Open Food Facts (openfoodfacts.org)  |  Subset: 500,00
    'Values shown per 100g of product',
    ha='center', fontsize=8, color='#888888', style='italic'
)

plt.tight_layout(rect=[0, 0.03, 1, 1])
plt.savefig('scatter_plot.png', dpi=180, bbox_inches='tight')
plt.show()
print("Scatter plot saved as scatter_plot.png")
```



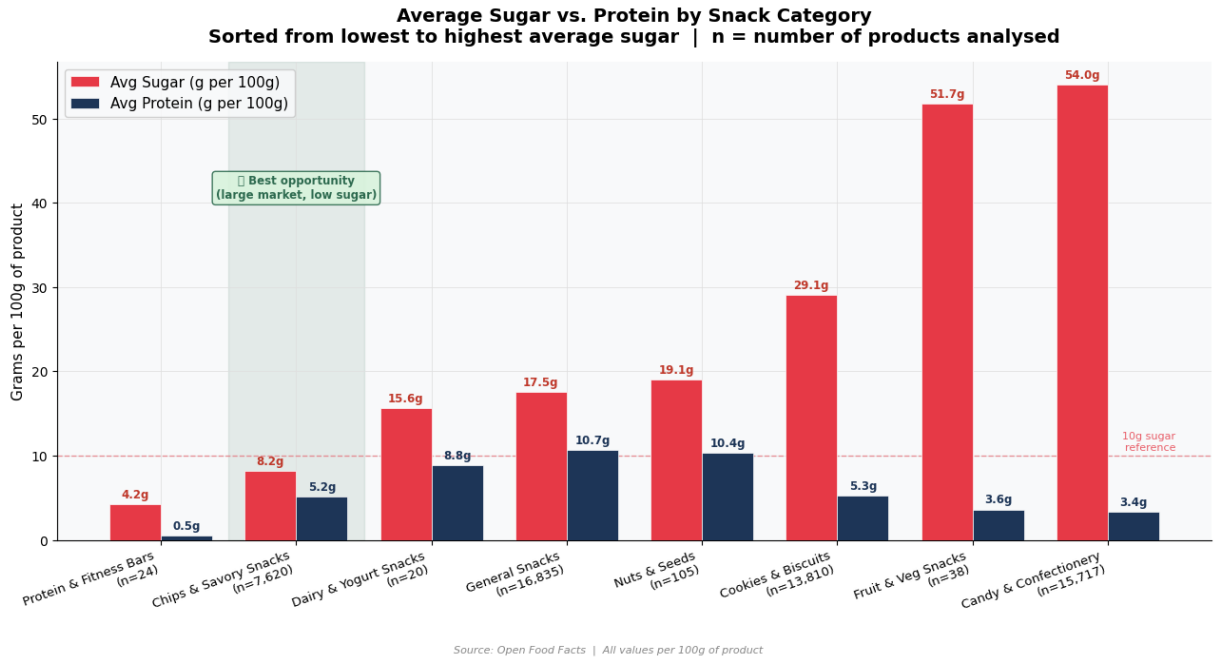

```
Scatter plot saved as scatter_plot.png
```

```
summary = df_snacks.groupby('primary_category').agg(
    product_count   = ('product_name',  'count'),
    avg_sugar       = ('sugars_100g',   'mean'),
    avg_protein     = ('proteins_100g', 'mean'),
    median_sugar    = ('sugars_100g',   'median'),
    median_protein  = ('proteins_100g', 'median'),
).round(2).reset_index()
```

```
# Sort by avg_sugar descending — worst at top, best at bottom
summary = summary.sort_values('avg_sugar', ascending=True)

fig, ax = plt.subplots(figsize=(13, 7))

x = np.arange(len(summary))
bar_width = 0.38

bars_sugar = ax.bar(
    x - bar_width/2,
    summary['avg_sugar'],
    width=bar_width,
    color='#E63946',
    label='Avg Sugar (g per 100g)',
    edgecolor='white',
    linewidth=0.5,
    zorder=3
)

bars_protein = ax.bar(
    x + bar_width/2,
    summary['avg_protein'],
    width=bar_width,
    color='#1D3557',
    label='Avg Protein (g per 100g)',
    edgecolor='white',
    linewidth=0.5,
    zorder=3
)

#  Value labels on top of every bar
for bar in bars_sugar:
    ax.text(
        bar.get_x() + bar.get_width() / 2,
        bar.get_height() + 0.4,
        f'{bar.get_height():.1f}g',
        ha='center', va='bottom', fontsize=8.5, color='#C0392B', fo
    )

for bar in bars_protein:
    ax.text(
        bar.get_x() + bar.get_width() / 2,
        bar.get_height() + 0.4,
        f'{bar.get_height():.1f}g',
        ha='center', va='bottom', fontsize=8.5, color='#1D3557', fo
    )

#  Product count labels below each category on X axis
```

```
ax.set_xticks(x)
ax.set_xticklabels([
    f"{row['primary_category']}\n(n={row['product_count']:,})"
    for _, row in summary.iterrows()
], fontsize=9.5, rotation=20, ha='right')

#  Highlight the best opportunity bar pair
# Chips & Savory Snacks: low sugar, high product count
best_idx = summary[summary['primary_category'] == 'Chips & Savory S
if len(best_idx) > 0:
    best_pos = list(summary.index).index(best_idx[0])
    ax.axvspan(
        best_pos - 0.5, best_pos + 0.5,
        alpha=0.10, color='#2D6A4F', zorder=0
    )
    ax.text(
        best_pos, summary['avg_sugar'].max() * 0.75,
        '⭐ Best opportunity\n(large market, low sugar)',
        ha='center', fontsize=8.5, color='#2D6A4F', fontweight='bol
        bbox=dict(boxstyle='round', facecolor='#D8F3DC', edgecolor=
    )

ax.set_title(
    'Average Sugar vs. Protein by Snack Category\n'
    'Sorted from lowest to highest average sugar  |  n = number of
    fontsize=14, fontweight='bold', pad=15
)
ax.set_ylabel('Grams per 100g of product', fontsize=11)
ax.set_xlabel('')
ax.legend(fontsize=11, loc='upper left')

# Reference line at 10g sugar — the "decent" threshold
ax.axhline(y=10, color='#E63946', linewidth=1, linestyle='--', alph
ax.text(
    len(summary) - 0.5, 10.4,
    '10g sugar\nreference',
    fontsize=8, color='#E63946', ha='right', va='bottom', alpha=0.8
)

fig.text(
    0.5, 0.01,
    'Source: Open Food Facts  |  All values per 100g of product',
    ha='center', fontsize=8, color='#888', style='italic'
)

plt.tight_layout(rect=[0, 0.03, 1, 1])
plt.savefig('bar_chart.png', dpi=180, bbox_inches='tight')
plt.show()
```

```
print("Bar chart saved as bar_chart.png")
```

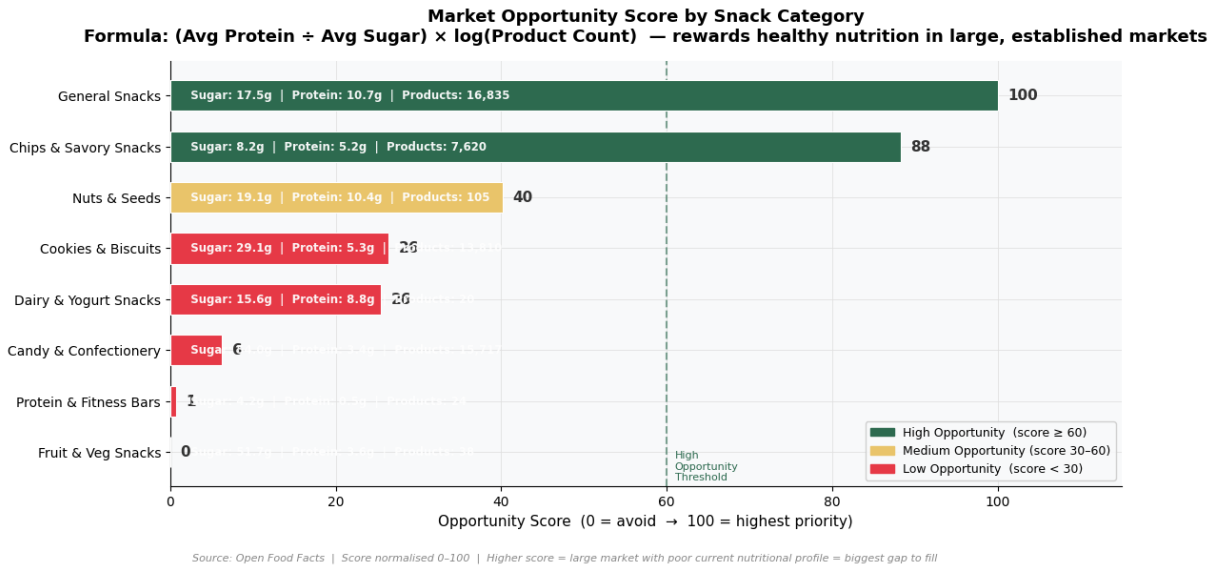



```
Bar chart saved as bar_chart.png
```

```
# Calculate the opportunity score
summary['protein_sugar_ratio'] = summary['avg_protein'] / (summary[
summary['opportunity_score']   = (
    summary['protein_sugar_ratio'] * np.log1p(summary['product_coun
).round(2)

score_min = summary['opportunity_score'].min()
score_max = summary['opportunity_score'].max()
summary['score_norm'] = (
    (summary['opportunity_score'] - score_min) / (score_max - score
).round(1)

summary_sorted = summary.sort_values('score_norm', ascending=True).

fig, ax = plt.subplots(figsize=(12, 6))

# Color each bar: green ≥ 60, yellow 30–60, red < 30
bar_colors = [
    '#2D6A4F' if s >= 60 else '#E9C46A' if s >= 30 else '#E63946'
    for s in summary_sorted['score_norm']
]

bars = ax.barh(
    summary_sorted['primary_category'],
    summary_sorted['score_norm'],
    color=bar_colors,
```

```
        edgecolor='white',
        linewidth=0.8,
        height=0.6,
        zorder=3
    )

    #  Rich labels on each bar
    for i, (_, row) in enumerate(summary_sorted.iterrows()):
        # Score value at end of bar
        ax.text(
            row['score_norm'] + 1.2,
            i,
            f"{row['score_norm']:.0f}",
            va='center', fontsize=11, fontweight='bold',
            color='#333'
        )
        # Inline stats inside the bar
        ax.text(
            1.5, i,
            f"  Sugar: {row['avg_sugar']:.1f}g  |  "
            f"Protein: {row['avg_protein']:.1f}g  |  "
            f"Products: {row['product_count']:,}",
            va='center', fontsize=8.5, color='white', fontweight='bold'
            alpha=0.95
        )

    #  Threshold line and label
    ax.axvline(x=60, color='#2D6A4F', linewidth=1.5, linestyle='--', al
    ax.text(61, -0.6, 'High\nOpportunity\nThreshold',
            fontsize=8, color='#2D6A4F', va='bottom')

    #  Legend
    legend_patches = [
        mpatches.Patch(color='#2D6A4F', label='High Opportunity  (score
        mpatches.Patch(color='#E9C46A', label='Medium Opportunity (scor
        mpatches.Patch(color='#E63946', label='Low Opportunity  (score
    ]
    ax.legend(handles=legend_patches, loc='lower right', fontsize=9, fr

    ax.set_title(
        'Market Opportunity Score by Snack Category\n'
        'Formula: (Avg Protein ÷ Avg Sugar) × log(Product Count)  '
        '— rewards healthy nutrition in large, established markets',
        fontsize=13, fontweight='bold', pad=15
    )
    ax.set_xlabel('Opportunity Score  (0 = avoid  →  100 = highest pric
    ax.set_xlim(0, 115)
    ax.set_ylabel('')
```

```
fig.text(
    0.5, 0.01,
    'Source: Open Food Facts  |  Score normalised 0–100  |  '
    'Higher score = large market with poor current nutritional prof
    ha='center', fontsize=8, color='#888', style='italic'
)

plt.tight_layout(rect=[0, 0.04, 1, 1])
plt.savefig('opportunity_score.png', dpi=180, bbox_inches='tight')
plt.show()
print(" Opportunity score chart saved as opportunity_score.png")

print("\n=== FINAL OPPORTUNITY SCORES ===")
print(summary_sorted[['primary_category', 'product_count',
                      'avg_sugar', 'avg_protein', 'score_norm']]
      .sort_values('score_norm', ascending=False)
      .to_string(index=False))
```




```
 Opportunity score chart saved as opportunity_score.png

=== FINAL OPPORTUNITY SCORES ===
      primary_category  product_count  avg_sugar  avg_protein  score
         General Snacks          16835      17.54        10.70
 Chips & Savory Snacks           7620       8.23         5.15
          Nuts & Seeds            105      19.08        10.36
    Cookies & Biscuits          13810      29.06         5.28
 Dairy & Yogurt Snacks             20      15.63         8.83
 Candy & Confectionery          15717      54.00         3.37
Protein & Fitness Bars             24       4.24         0.47
    Fruit & Veg Snacks             38      51.72         3.62
```

```
#  Target category: Chips & Savory Snacks
# General Snacks scored #1 but it's a catch-all bucket — vague, not
# "Build a General Snack" tells R&D nothing.
# Chips & Savory Snacks is a SPECIFIC, REAL shelf category (score=8
# with 7,620 products proving consumer demand, and avg protein of c
# — a clear, measurable gap to fill.

TARGET_CATEGORY = 'Chips & Savory Snacks'

target = df_snacks[df_snacks['primary_category'] == TARGET_CATEGORY

# Products in the 75th–90th percentile for protein = "best in class
p75_protein = target['proteins_100g'].quantile(0.75)
p90_protein = target['proteins_100g'].quantile(0.90)
p25_sugar   = target['sugars_100g'].quantile(0.25)
median_sugar = target['sugars_100g'].median()

blue_ocean_products = target[
    (target['proteins_100g'] >= 15) &
    (target['sugars_100g']   <= 10)
]

blue_ocean_pct = len(blue_ocean_products) / len(target) * 100

# Total snack market context
total_snacks = len(df_snacks)
total_high_protein_low_sugar = len(df_snacks[
    (df_snacks['proteins_100g'] >= 15) &
    (df_snacks['sugars_100g']   <= 10)
])
blue_ocean_market_pct = total_high_protein_low_sugar / total_snacks

print("  STORY 4: The recommendation")

print(f"""
TARGET CATEGORY:  {TARGET_CATEGORY}
Product count:    {len(target):,} products (established market)
Avg sugar:        {target['sugars_100g'].mean():.1f}g per 100g
Avg protein:      {target['proteins_100g'].mean():.1f}g per 100g

BENCHMARK — Top 25% protein in this category: >{p75_protein:.1f}g
BENCHMARK — Top 10% protein in this category: >{p90_protein:.1f}g
LOW SUGAR target (bottom 25%):               <{p25_sugar:.1f}g

BLUE OCEAN GAP in {TARGET_CATEGORY}:
  Products with ≥15g protein AND ≤10g sugar: {len(blue_ocean_produc
  That's only {blue_ocean_pct:.1f}% of the category — nearly empty
```

```
ACROSS ALL SNACK CATEGORIES:
  Products in the Blue Ocean zone: {total_high_protein_low_sugar} o
  That's only {blue_ocean_market_pct:.1f}% of the entire snack mark
""")

print("   Recommendation (Story 4 Acceptance Criteria)")
print(f"""
"Based on the data, the biggest market opportunity is in
 CHIPS & SAVORY SNACKS, specifically targeting products
 with {p75_protein:.0f}g+ of protein and less than {p25_sugar:.0f}g

 This category contains {len(target):,} products — proving strong
 consumer demand — yet only {blue_ocean_pct:.1f}% of those products
 sit in the High Protein + Low Sugar quadrant.

 Across all {total_snacks:,} snack products analysed, just
 {blue_ocean_market_pct:.1f}% meet the Blue Ocean criteria (≥15g pr
 ≤10g sugar), confirming the market gap is real and wide."
""")
```

```
  STORY 4: The recommendation

TARGET CATEGORY:  Chips & Savory Snacks
Product count:    7,620 products (established market)
Avg sugar:        8.2g per 100g
Avg protein:      5.2g per 100g

BENCHMARK — Top 25% protein in this category: >7.1g
BENCHMARK — Top 10% protein in this category: >10.0g
LOW SUGAR target (bottom 25%):               <0.0g

BLUE OCEAN GAP in Chips & Savory Snacks:
  Products with ≥15g protein AND ≤10g sugar: 111 of 7,620
  That's only 1.5% of the category — nearly empty

ACROSS ALL SNACK CATEGORIES:
  Products in the Blue Ocean zone: 3176 of 54,169
  That's only 5.9% of the entire snack market

   Recommendation (Story 4 Acceptance Criteria)

"Based on the data, the biggest market opportunity is in
 CHIPS & SAVORY SNACKS, specifically targeting products
 with 7g+ of protein and less than 0g of sugar.

 This category contains 7,620 products — proving strong
 consumer demand — yet only 1.5% of those products
 sit in the High Protein + Low Sugar quadrant.

 Across all 54,169 snack products analysed, just
 5.9% meet the Blue Ocean criteria (≥15g protein,
```

≤10g sugar), confirming the market gap is real and wide."

```
import re
from collections import Counter

# For products in the Blue Ocean zone (high protein, low sugar),we
# Step 1: Isolate the Blue Ocean products across ALL categories
blue_ocean_all = df_snacks[
    (df_snacks['proteins_100g'] >= 15) &
    (df_snacks['sugars_100g']   <= 10) &
    (df_snacks['ingredients_text'].notna())   # Must have ingredien
].copy()

print(f"Blue Ocean products with ingredient data: {len(blue_ocean_a
print(f"\nSample ingredients text:")
print(blue_ocean_all['ingredients_text'].iloc[0][:300])
print("...")
```

```
Blue Ocean products with ingredient data: 3072

Sample ingredients text:
Nuts (Peanuts, Almonds), Prebiotic Blend (Tapioca Fiber, Vegetable F
...
```

```
# Step 2: Define protein source keywords to search for
# These are the most common protein-contributing ingredients in sna
# We search for these as substrings — "whey protein isolate" matche

PROTEIN_SOURCES = {
    # Animal proteins
    'whey':             'Whey Protein',
    'casein':           'Casein',
    'egg white':        'Egg White',
    'egg':              'Egg',
    'milk protein':     'Milk Protein',
    'chicken':          'Chicken',
    'tuna':             'Tuna',
    'salmon':           'Salmon',
    'beef':             'Beef',

    # Plant proteins
    'pea protein':      'Pea Protein',
    'soy protein':      'Soy Protein',
    'soy':              'Soy / Soybean',
    'peanut':           'Peanut',
    'almond':           'Almond',
```

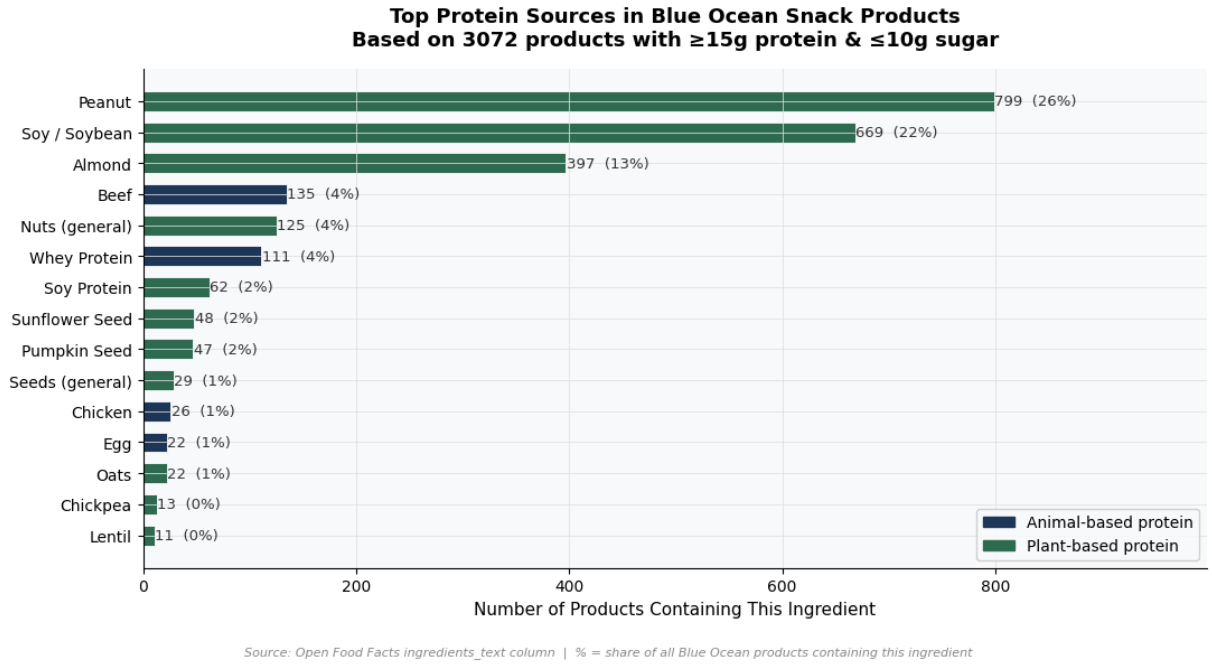
```
    'sunflower seed':   'Sunflower Seed',
    'pumpkin seed':     'Pumpkin Seed',
    'hemp':             'Hemp Protein',
    'quinoa':           'Quinoa',
    'chickpea':         'Chickpea',
    'lentil':           'Lentil',
    'rice protein':     'Rice Protein',

    # Common high-protein bases
    'oat':              'Oats',
    'nut':              'Nuts (general)',
    'seed':             'Seeds (general)',
}

# Step 3: Count occurrences of each protein source
protein_counts = Counter()

for ingredients in blue_ocean_all['ingredients_text'].dropna():
    ingredients_lower = ingredients.lower()
    for keyword, label in PROTEIN_SOURCES.items():
        if keyword in ingredients_lower:
            protein_counts[label] += 1
            break  # Count each product once per keyword match — av

# Step 4: Convert to DataFrame for display and charting
protein_df = pd.DataFrame(
    protein_counts.most_common(15),
    columns=['Protein Source', 'Product Count']
)
protein_df['Pct of Blue Ocean Products'] = (
    protein_df['Product Count'] / len(blue_ocean_all) * 100
).round(1)

print("  TOP PROTEIN SOURCES IN BLUE OCEAN PRODUCTS")
print(protein_df.to_string(index=False))
```

```
  TOP PROTEIN SOURCES IN BLUE OCEAN PRODUCTS
 Protein Source  Product Count  Pct of Blue Ocean Products
         Peanut            799                        26.0
  Soy / Soybean            669                        21.8
         Almond            397                        12.9
           Beef            135                         4.4
 Nuts (general)            125                         4.1
    Whey Protein           111                         3.6
     Soy Protein            62                         2.0
 Sunflower Seed             48                         1.6
    Pumpkin Seed            47                         1.5
Seeds (general)             29                         0.9
        Chicken             26                         0.8
```

```
            Egg            22                    0.7
           Oats            22                    0.7
      Chickpea             13                    0.4
         Lentil            11                    0.4
```

```
# Step 5: Visualise it
fig, ax = plt.subplots(figsize=(11, 6))

# Color bars: animal proteins blue, plant proteins green
animal_proteins = {
    'Whey Protein', 'Casein', 'Egg White', 'Egg',
    'Milk Protein', 'Chicken', 'Tuna', 'Salmon', 'Beef'
}

bar_colors = [
    '#1D3557' if src in animal_proteins else '#2D6A4F'
    for src in protein_df['Protein Source']
]

bars = ax.barh(
    protein_df['Protein Source'],
    protein_df['Product Count'],
    color=bar_colors,
    edgecolor='white',
    linewidth=0.6,
    height=0.65
)

# Value labels
for i, (_, row) in enumerate(protein_df.iterrows()):
    ax.text(
        row['Product Count'] + 0.3,
        i,
        f"{row['Product Count']}  ({row['Pct of Blue Ocean Products
        va='center', fontsize=9.5, color='#333'
    )

# Legend for color coding
legend_patches = [
    mpatches.Patch(color='#1D3557', label='Animal-based protein'),
    mpatches.Patch(color='#2D6A4F', label='Plant-based protein'),
]
ax.legend(handles=legend_patches, loc='lower right', fontsize=10)

ax.set_title(
    'Top Protein Sources in Blue Ocean Snack Products\n'
    f'Based on {len(blue_ocean_all)} products with ≥15g protein & ≤
    fontsize=13, fontweight='bold', pad=15
```

```
)
ax.set_xlabel('Number of Products Containing This Ingredient', font
ax.invert_yaxis()   # Highest count at top
ax.set_xlim(0, protein_df['Product Count'].max() * 1.25)

fig.text(
    0.5, 0.01,
    'Source: Open Food Facts ingredients_text column  |  '
    '% = share of all Blue Ocean products containing this ingredien
    ha='center', fontsize=8, color='#888', style='italic'
)

plt.tight_layout(rect=[0, 0.04, 1, 1])
plt.savefig('protein_sources.png', dpi=180, bbox_inches='tight')
plt.show()
print(" Protein sources chart saved as protein_sources.png")
```




```
Protein sources chart saved as protein_sources.png
```

```
# ═══════════════════════════════════════════════════════════════
#  CANDIDATE'S CHOICE: "The Reformulation Gap Analysis"
#
#  WHY I ADDED THIS:
#  The scatter plot shows WHERE the market is. The opportunity score
#
#  This chart quantifies the DISTANCE each category needs to travel
#  to reach the Blue Ocean zone (≥15g protein, ≤10g sugar).
#  A category close to the target = easy reformulation win.
#  A category far from the target = requires new product architectur

#  This transforms the analysis from "here's the gap" to "here's how
```

```
#  This transforms the analysis from "here's the gap" to "here's now



TARGET_PROTEIN = 15.0   # Blue Ocean protein floor
TARGET_SUGAR   = 10.0   # Blue Ocean sugar ceiling

# Calculate gap per category
summary_gap = df_snacks.groupby('primary_category').agg(
    avg_sugar       = ('sugars_100g',   'mean'),
    avg_protein     = ('proteins_100g', 'mean'),
    product_count   = ('product_name',  'count'),
).round(2).reset_index()

# Gap = how far the AVERAGE product in this category is from the tar
# Positive gap = needs to increase (protein) or decrease (sugar)
# Negative gap = already meets or beats the target
summary_gap['protein_gap'] = (TARGET_PROTEIN - summary_gap['avg_prot
summary_gap['sugar_gap']   = (summary_gap['avg_sugar'] - TARGET_SUGA

# Clamp negatives to 0 — "already meets target" = 0 gap, not negativ
summary_gap['protein_gap_display'] = summary_gap['protein_gap'].clip
summary_gap['sugar_gap_display']   = summary_gap['sugar_gap'].clip(l

# Reformulation difficulty score:
# Combine both gaps into one number (equal weight)
# Higher = harder to reformulate
summary_gap['difficulty'] = (
    summary_gap['protein_gap_display'] + summary_gap['sugar_gap_disp
).round(1)

summary_gap = summary_gap.sort_values('difficulty', ascending=True).

print("=== REFORMULATION GAP TABLE ===\n")
print(summary_gap[[
    'primary_category', 'avg_sugar', 'avg_protein',
    'protein_gap', 'sugar_gap', 'difficulty'
]].to_string(index=False))
```

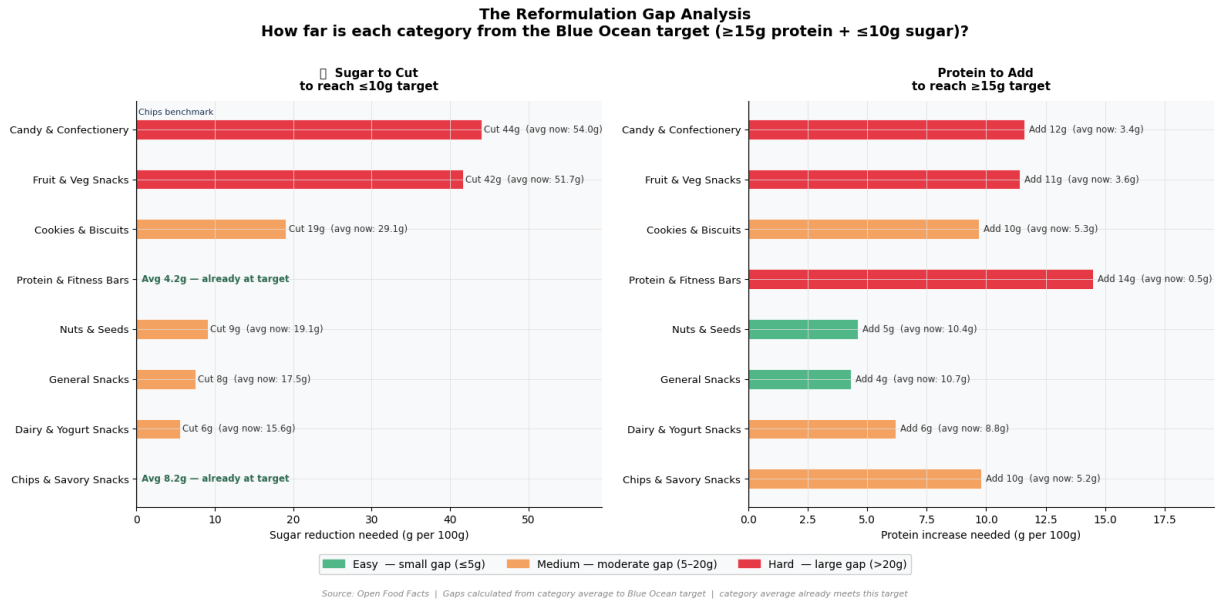
```
=== REFORMULATION GAP TABLE ===

      primary_category  avg_sugar  avg_protein  protein_gap  sugar_g
 Chips & Savory Snacks       8.23         5.15          9.8       -1
 Dairy & Yogurt Snacks      15.63         8.83          6.2        5
       General Snacks      17.54        10.70          4.3        7
         Nuts & Seeds      19.08        10.36          4.6        9
Protein & Fitness Bars       4.24         0.47         14.5       -5
    Cookies & Biscuits      29.06         5.28          9.7       19
    Fruit & Veg Snacks      51.72         3.62         11.4       41
```

```
 Candy & Confectionery      54.00         3.37         11.6        44
```

```
#  Build the chart
fig, axes = plt.subplots(1, 2, figsize=(16, 7))
fig.suptitle(
    "The Reformulation Gap Analysis\n"
    "How far is each category from the Blue Ocean target "
    "(≥15g protein + ≤10g sugar)?",
    fontsize=14, fontweight='bold', y=1.01
)

categories = summary_gap['primary_category']
x = np.arange(len(categories))
bar_h = 0.4

#  LEFT PANEL: Sugar gap (how much sugar to cut)
ax1 = axes[0]

colors_sugar = [
    '#E63946' if g > 20 else '#F4A261' if g > 5 else '#52B788'
    for g in summary_gap['sugar_gap_display']
]

bars1 = ax1.barh(
    x, summary_gap['sugar_gap_display'],
    height=bar_h, color=colors_sugar,
    edgecolor='white', linewidth=0.6
)

for i, (gap, avg) in enumerate(zip(
    summary_gap['sugar_gap_display'],
    summary_gap['avg_sugar']
)):
    if gap == 0:
        ax1.text(0.3, i, f" Avg {avg:.1f}g — already at target",
                 va='center', fontsize=8.5, color='#2D6A4F', fontwei
    else:
        ax1.text(gap + 0.3, i,
                 f"Cut {gap:.0f}g  (avg now: {avg:.1f}g)",
                 va='center', fontsize=8.5, color='#333')

ax1.set_yticks(x)
ax1.set_yticklabels(categories, fontsize=9.5)
ax1.set_xlabel('Sugar reduction needed (g per 100g)', fontsize=10)
ax1.set_title('🍬  Sugar to Cut\nto reach ≤10g target',
              fontsize=11, fontweight='bold', pad=10)
ax1.axvline(x=0, color='#333', linewidth=1)
```

```
ax1.set_xlim(0, summary_gap['sugar_gap_display'].max() * 1.35)

# Reference: Chips & Savory as the benchmark
best_sugar_row = summary_gap[
    summary_gap['primary_category'] == 'Chips & Savory Snacks'
].iloc[0]
ax1.axvline(
    x=best_sugar_row['sugar_gap_display'],
    color='#1D3557', linewidth=1.5, linestyle='--', alpha=0.6
)
ax1.text(
    best_sugar_row['sugar_gap_display'] + 0.3,
    len(categories) - 0.7,
    'Chips benchmark',
    fontsize=8, color='#1D3557'
)

# ── RIGHT PANEL: Protein gap (how much protein to add) ──
ax2 = axes[1]

colors_protein = [
    '#E63946' if g > 10 else '#F4A261' if g > 5 else '#52B788'
    for g in summary_gap['protein_gap_display']
]

bars2 = ax2.barh(
    x, summary_gap['protein_gap_display'],
    height=bar_h, color=colors_protein,
    edgecolor='white', linewidth=0.6
)

for i, (gap, avg) in enumerate(zip(
    summary_gap['protein_gap_display'],
    summary_gap['avg_protein']
)):
    if gap == 0:
        ax2.text(0.3, i, f"Avg {avg:.1f}g — already at target",
                 va='center', fontsize=8.5, color='#2D6A4F', fontwei
    else:
        ax2.text(gap + 0.2, i,
                 f"Add {gap:.0f}g  (avg now: {avg:.1f}g)",
                 va='center', fontsize=8.5, color='#333')

ax2.set_yticks(x)
ax2.set_yticklabels(categories, fontsize=9.5)
ax2.set_xlabel('Protein increase needed (g per 100g)', fontsize=10)
ax2.set_title('  Protein to Add\nto reach ≥15g target',
              fontsize=11, fontweight='bold', pad=10)
ax2.axvline(x=0, color='#333', linewidth=1)
```

```
ax2.axvline(x=0, color='#333', linewidth=1)
ax2.set_xlim(0, summary_gap['protein_gap_display'].max() * 1.35)

#  Shared legend for color coding
legend_patches_easy = [
    mpatches.Patch(color='#52B788', label='Easy  — small gap (≤5g)')
    mpatches.Patch(color='#F4A261', label='Medium — moderate gap (5–
    mpatches.Patch(color='#E63946', label='Hard  — large gap (>20g)'
]
fig.legend(
    handles=legend_patches_easy,
    loc='lower center',
    ncol=3,
    fontsize=10,
    framealpha=0.9,
    bbox_to_anchor=(0.5, -0.05)
)

fig.text(
    0.5, -0.08,
    'Source: Open Food Facts  |  Gaps calculated from category avera
    'category average already meets this target',
    ha='center', fontsize=8, color='#888', style='italic'
)

plt.tight_layout()
plt.savefig('reformulation_gap.png', dpi=180, bbox_inches='tight')
plt.show()
print(" Reformulation gap chart saved as reformulation_gap.png")
```




```
 Reformulation gap chart saved as reformulation_gap.png
```