In [1]:

```
import numpy as np
import pandas as pd

import seaborn as sns
import matplotlib
import matplotlib.pyplot as plt

import re


%matplotlib inline

import pandas_profiling # утилита, удобна для знакомства с данными
# с её помощью можно получить кучу описательных статистик по датасету

from wordcloud import WordCloud

import os

from PIL import Image

from sklearn.model_selection import train_test_split

# Кодирование категориальных переменных
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import OneHotEncoder
import category_encoders as ce

# Шкалирование переменных
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import RobustScaler

from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_auc_score, roc_curve

# Модели
from sklearn.linear_model import LogisticRegression, LogisticRegressionCV
from sklearn.model_selection import StratifiedKFold

from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV

import xgboost as xgb
from xgboost import XGBClassifier
import time
from sklearn.metrics import cohen_kappa_score, make_scorer
from imblearn.over_sampling import SMOTE

from sklearn.linear_model import SGDClassifier, LogisticRegressionCV
# SGD - стохастический градиентный спуск

from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.ensemble import GradientBoostingClassifier
from graphviz import Source
```

```
import sklearn
import lightgbm as lgb
from catboost import CatBoostClassifier
```

In [3]:

```
data = pd.read_csv("train/train.csv")

breeds = pd.read_csv('breed_labels.csv') # словарь пород
colors = pd.read_csv('color_labels.csv') # словарь окрасов шерсти
states = pd.read_csv('state_labels.csv') # словарь местоположения

data.shape
```

Out[3]:

```
(14993, 24)
```

In [5]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14993 entries, 0 to 14992
Data columns (total 24 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   Type           14993 non-null  int64  
 1   Name           13736 non-null  object 
 2   Age            14993 non-null  int64  
 3   Breed1         14993 non-null  int64  
 4   Breed2         14993 non-null  int64  
 5   Gender         14993 non-null  int64  
 6   Color1         14993 non-null  int64  
 7   Color2         14993 non-null  int64  
 8   Color3         14993 non-null  int64  
 9   MaturitySize   14993 non-null  int64  
 10  FurLength      14993 non-null  int64  
 11  Vaccinated     14993 non-null  int64  
 12  Dewormed       14993 non-null  int64  
 13  Sterilized     14993 non-null  int64  
 14  Health         14993 non-null  int64  
 15  Quantity       14993 non-null  int64  
 16  Fee            14993 non-null  int64  
 17  State          14993 non-null  int64  
 18  RescuerID      14993 non-null  object 
 19  VideoAmt       14993 non-null  int64  
 20  Description    14981 non-null  object 
 21  PetID          14993 non-null  object 
 22  PhotoAmt       14993 non-null  float64
 23  AdoptionSpeed  14993 non-null  int64  
dtypes: float64(1), int64(19), object(4)
memory usage: 2.7+ MB
```

In [6]:

```
data.describe()
```

Out[6]:

	Type	Age	Breed1	Breed2	Gender	Color1	
count	14993.000000	14993.000000	14993.000000	14993.000000	14993.000000	14993.000000	14
mean	1.457614	10.452078	265.272594	74.009738	1.776162	2.234176	
std	0.498217	18.155790	60.056818	123.011575	0.681592	1.745225	
min	1.000000	0.000000	0.000000	0.000000	1.000000	1.000000	
25%	1.000000	2.000000	265.000000	0.000000	1.000000	1.000000	
50%	1.000000	3.000000	266.000000	0.000000	2.000000	2.000000	
75%	2.000000	12.000000	307.000000	179.000000	2.000000	3.000000	
max	2.000000	255.000000	307.000000	307.000000	3.000000	7.000000	

In [7]:

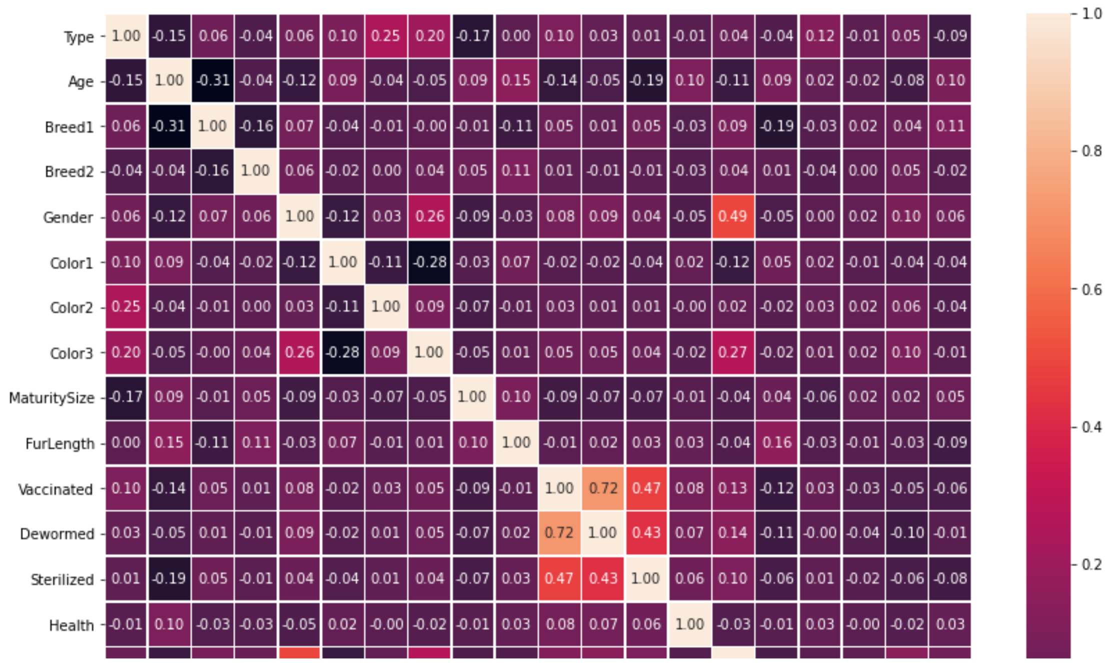
```
missing = data.isnull().sum().to_frame(name = "count_of_missing_values")
missing["%"] = data.isnull().sum() / len(data)
missing
```

Out[7]:

	count_of_missing_values	%
Type	0	0.000000
Name	1257	0.083839
Age	0	0.000000
Breed1	0	0.000000
Breed2	0	0.000000
Gender	0	0.000000
Color1	0	0.000000
Color2	0	0.000000
Color3	0	0.000000
MaturitySize	0	0.000000
FurLength	0	0.000000

In [8]:

```
#correlation map
plt.figure(figsize=(14, 12))
sns.heatmap(data.corr(), annot=True, linewidths=.5, fmt= '.2f')
plt.show()
```



In [9]:

```
data.columns
```

Out[9]:

```
Index(['Type', 'Name', 'Age', 'Breed1', 'Breed2', 'Gender', 'Color1', 'Color
2',
       'Color3', 'MaturitySize', 'FurLength', 'Vaccinated', 'Dewormed',
       'Sterilized', 'Health', 'Quantity', 'Fee', 'State', 'RescuerID',
       'VideoAmt', 'Description', 'PetID', 'PhotoAmt', 'AdoptionSpeed'],
      dtype='object')
```

Тип животного:

1 - собака

2 - кот

In [10]:

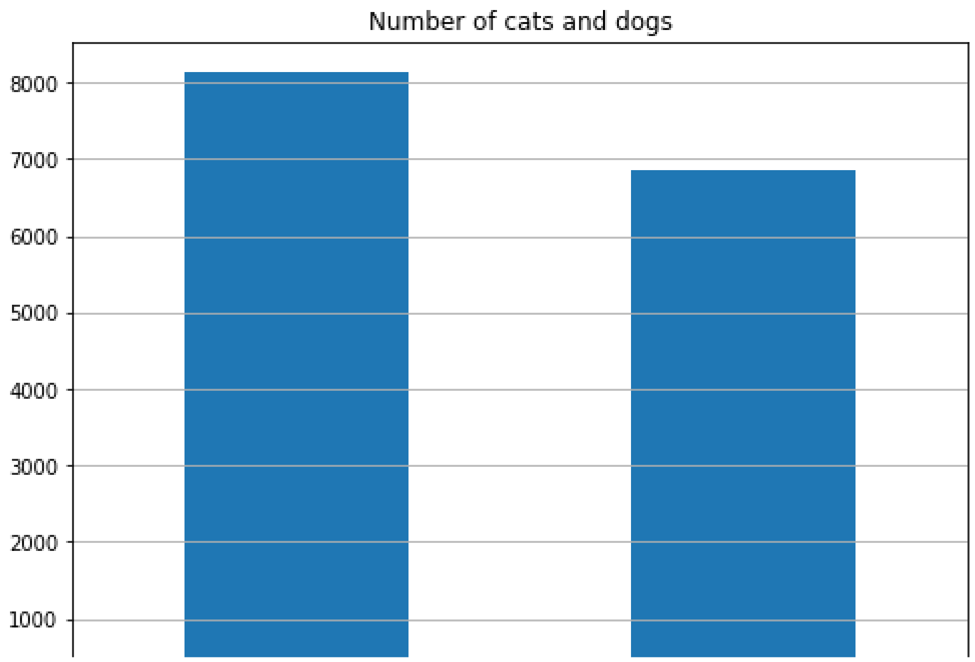
```
data["Type"] = data["Type"].apply(lambda x: "dog" if x == 1 else "cat")
animals = data["Type"].value_counts().to_frame("count")
animals["%"] = data["Type"].value_counts(normalize = True)
animals
```

Out[10]:

	count	%
dog	8132	0.542386
cat	6861	0.457614

In [11]:

```
data["Type"].value_counts().plot.bar(figsize=(8, 6), rot = 0)
plt.grid(axis='y')
plt.title('Number of cats and dogs');
```



Имена

In [12]:

```
data["Name"]
```

Out[12]:

```
0                Nibble
1           No Name Yet
2                Brisco
3                  Miko
4                Hunter
              ...
14988               NaN
14989    Serato & Eddie
14990           Monkies
14991           Ms Daym
14992              Fili
Name: Name, Length: 14993, dtype: object
```

In [13]:

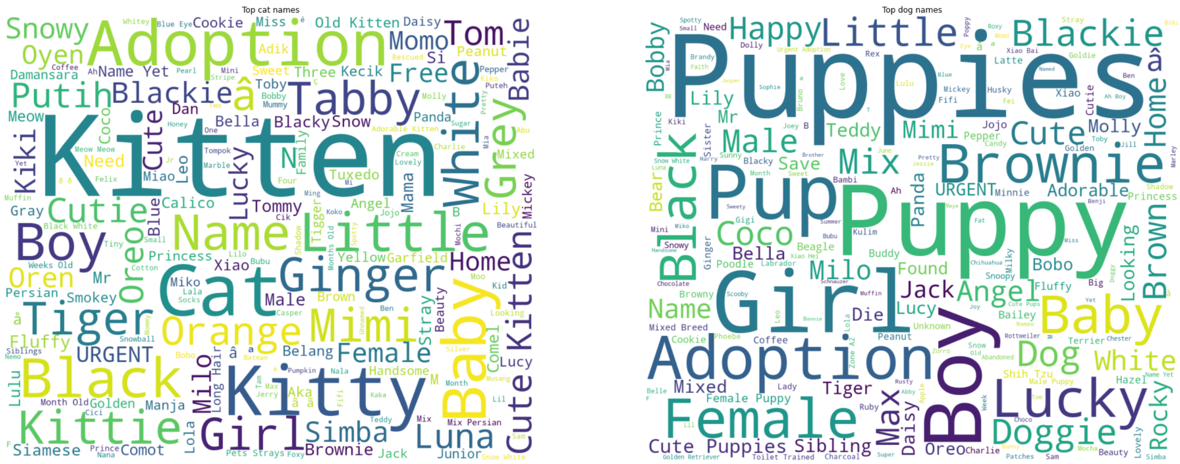
```
data["Name"].values
```

Out[13]:

```
array(['Nibble', 'No Name Yet', 'Brisco', ..., 'Monkies', 'Ms Daym',
       'Fili'], dtype=object)
```

In [14]:

```
fig, ax = plt.subplots(figsize = (32, 24))
plt.subplot(1, 2, 1)
text_cat = ' '.join(data.loc[data['Type'] == 'cat', 'Name'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white',
                      width=1200, height=1000).generate(text_cat)
plt.imshow(wordcloud)
plt.title('Top cat names')
plt.axis("off")

plt.subplot(1, 2, 2)
text_dog = ' '.join(data.loc[data['Type'] == 'dog', 'Name'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white',
                      width=1200, height=1000).generate(text_dog)
plt.imshow(wordcloud)
plt.title('Top dog names')
plt.axis("off")

plt.show()
```



In [15]:

```
data.fillna('no_name', inplace = True)
```

In [16]:

```
names = set()
for x in data["Name"].fillna('').values:
    strn = x.lower()
    if (strn.find("name") != -1 and (strn.find("no") != -1 or strn.find("un") != -1 or
                                     strn.find("less") != -1 or strn.find("haven't") != -1)):
        names.add(x)
# for x in names:
#     print(x)
```

In [17]:

```
for x in data["Name"]:
    if len(x) < 3 or re.search(r"\d+", x) is not None:
        names.add(x)
        # print(x)
```

In [18]:

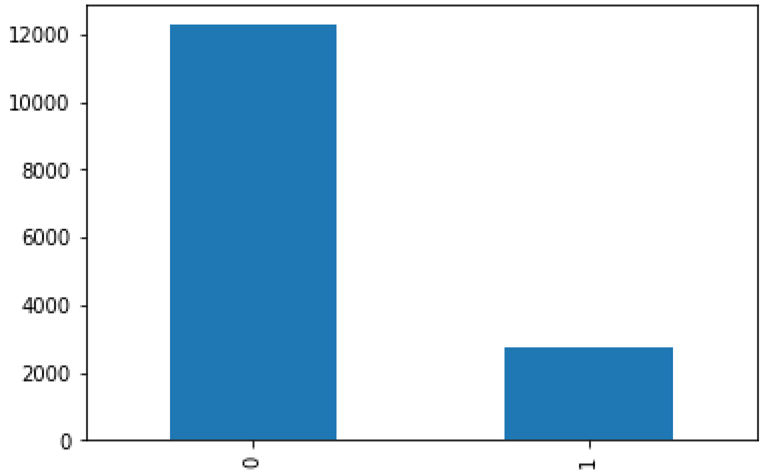
```
for x in names:
    data.loc[data['Name'] == x, 'Name'] = "no_name"
```

In [19]:

```
data["No_name"] = 0
data.loc[data['Name'] == 'no_name', 'No_name'] = 1
data["No_name"].value_counts().plot.bar()
```

Out[19]:

```
<AxesSubplot:>
```



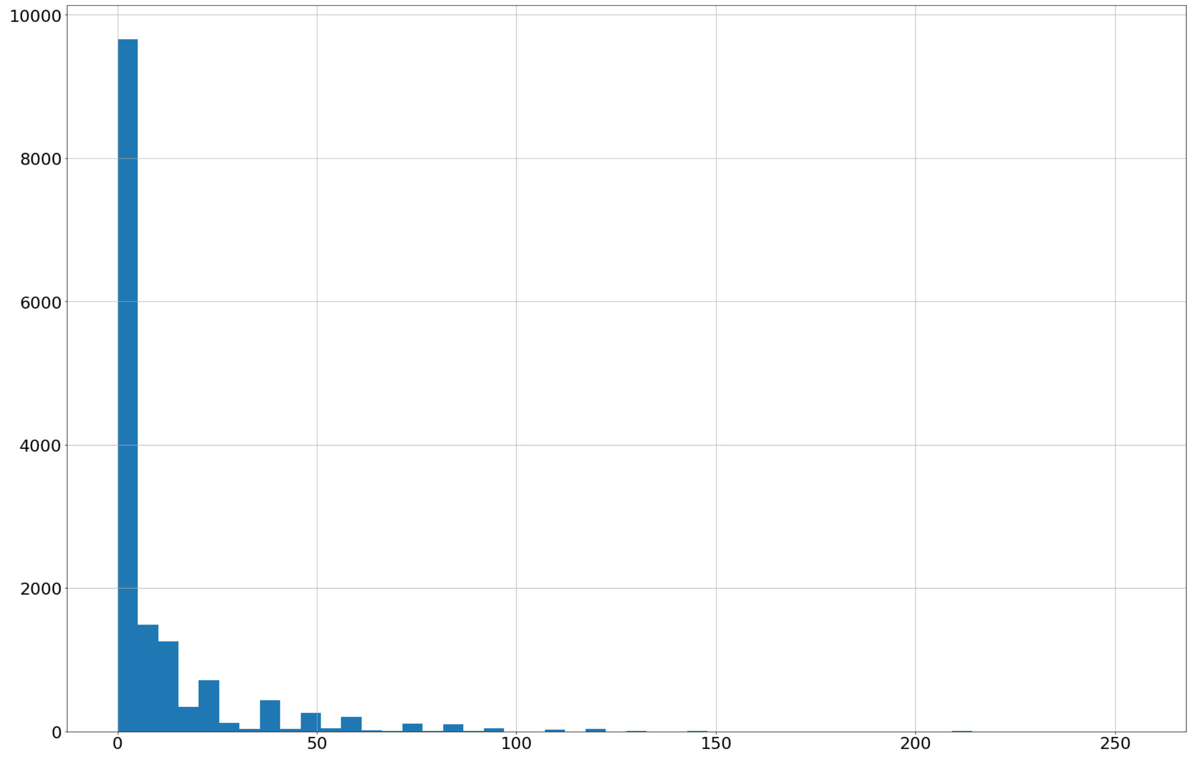
Возраст (в месяцах)

In [20]:

```
data["Age"].hist(bins = 50, figsize = (30, 20), xlabelsize = 25, ylabelsize = 25)
```

Out[20]:

```
<AxesSubplot:>
```



In [21]:

```
data["Age"].value_counts().sort_index()
```

Out[21]:

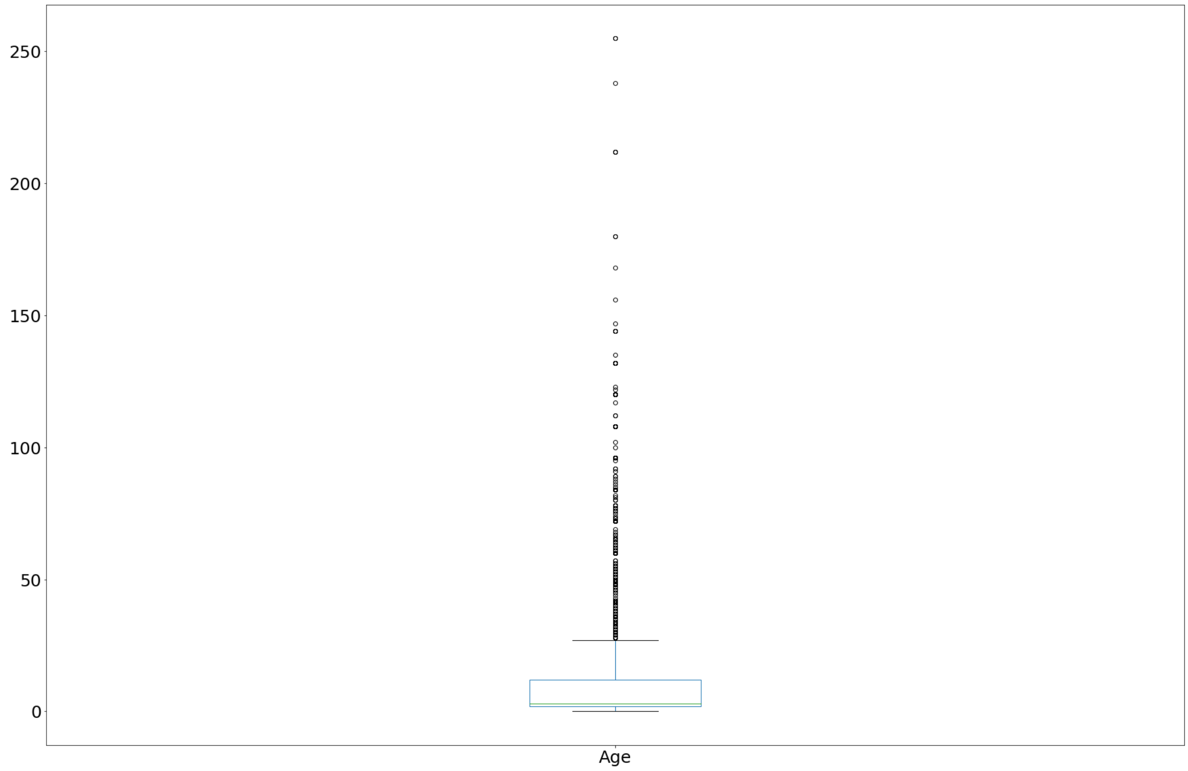
```
0       179
1      2304
2      3503
3      1966
4      1109
       ...
168       1
180       2
212       3
238       1
255       2
Name: Age, Length: 106, dtype: int64
```

In [22]:

```
data["Age"].plot.box(figsize = (30, 20), fontsize = 25)
```

Out[22]:

```
<AxesSubplot:>
```



In [31]:

```
def outlier_detect_IQR(data,col,threshold=3):
    IQR = data[col].quantile(0.75) - data[col].quantile(0.25)
    lower = data[col].quantile(0.25) - (IQR * threshold)
    upper = data[col].quantile(0.75) + (IQR * threshold)
    borders = (upper, lower)
    emiss = pd.concat([data[col] > upper, data[col] < lower],axis=1)
    outlier_index = emiss.any(axis=1)
    print('Количество выбросов в данных:', outlier_index.value_counts()[1])
    print('Доля выбросов:',outlier_index.value_counts()[1]/len(outlier_index))
    return outlier_index, borders
```

In [32]:

```
index,para = outlier_detect_IQR(data=data,col='Age',threshold=1)
print('Верхняя граница:',para[0],'\nНижняя граница:',para[1])
```

```
Количество выбросов в данных: 2200
Доля выбросов: 0.1467351430667645
Верхняя граница: 22.0
Нижняя граница: -8.0
```

In [33]:

```
data.loc[index,'Age'].sort_values()
```

Out[33]:

```
2180      23
10492     23
834       23
14182     23
9425      23
        ...
3998     212
11087    212
13398    238
5160     255
11172    255
Name: Age, Length: 2200, dtype: int64
```

In [34]:

```
data["Age"].min()
```

Out[34]:

```
0
```

Заменим выбросы выборочным значением

In [35]:

```
def impute_outlier_with_arbitrary(data,outlier_index,value,col=[]):
    data_copy = data.copy(deep=True)
    for i in col:
        data_copy.loc[outlier_index,i] = value
    return data_copy
```

In [36]:

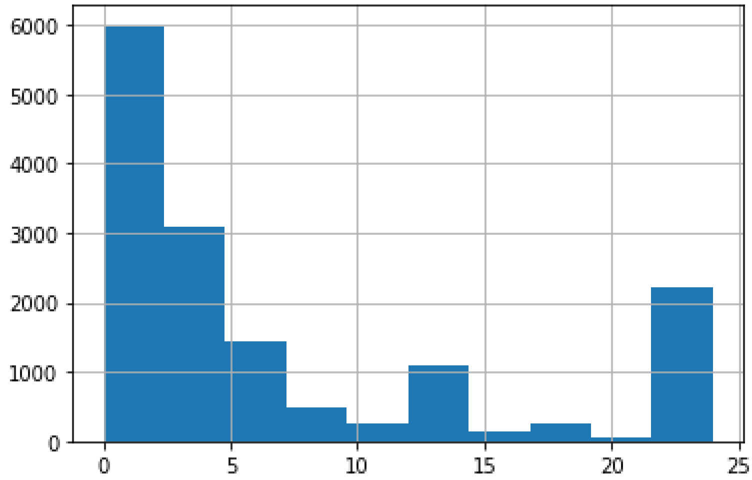
```
data = impute_outlier_with_arbitrary(data=data,outlier_index=index, value= 24, col=['Age'])
```

In [37]:

```
data["Age"].hist()
```

Out[37]:

<AxesSubplot:>



Порода

In [40]:

```
data['Pure_breed'] = 0
data.loc[data['Breed2'] == 0, 'Pure_breed'] = 1
print(f"Доля чистокровных животных = {round(data['Pure_breed'].sum()/len(data), 2)} %")
```

Доля чистокровных животных = 0.72 %

In [41]:

```
breeds_dict = {k: v for k, v in zip(breeds['BreedID'], breeds['BreedName'])}
breeds_dict
```

Out[41]:

```
{1: 'Affenpinscher',
 2: 'Afghan Hound',
 3: 'Airedale Terrier',
 4: 'Akbash',
 5: 'Akita',
 6: 'Alaskan Malamute',
 7: 'American Bulldog',
 8: 'American Eskimo Dog',
 9: 'American Hairless Terrier',
 10: 'American Staffordshire Terrier',
 11: 'American Water Spaniel',
 12: 'Anatolian Shepherd',
 13: 'Appenzell Mountain Dog',
 14: 'Australian Cattle Dog/Blue Heeler',
 15: 'Australian Kelpie',
 16: 'Australian Shepherd',
 17: 'Australian Terrier',
 18: 'Basenji',
```

In [42]:

```
data['Breed1_name'] = data['Breed1'].apply(lambda x: '_'.join(breeds_dict[x].split()) if x
data['Breed2_name'] = data['Breed2'].apply(lambda x: '_'.join(breeds_dict[x].split()) if x
data
```

Out[42]:

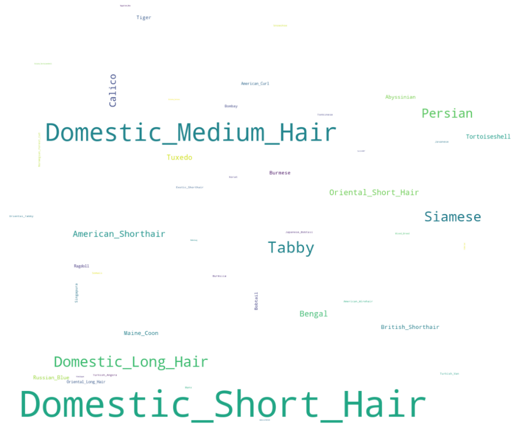
	Type	Name	Age	Breed1	Breed2	Gender	Color1	Color2	Color3	MaturitySize	...
0	cat	Nibble	3	299	0	1	1	7	0	1	...
1	cat	no_name	1	265	0	1	1	2	0	2	...
2	dog	Brisco	1	307	0	1	2	7	0	2	...
3	dog	Miko	4	307	0	2	1	2	0	2	...
4	dog	Hunter	1	307	0	1	1	0	0	2	...
...	...	...	...	...	...	...	...	...	...	...	...
14988	cat	no_name	2	266	0	3	1	0	0	2	...
14989	cat	Serato & Eddie	24	265	264	3	1	4	7	2	...
14990	cat	Monkies	2	265	266	3	5	6	7	3	...
14991	cat	Ms Daym	9	266	0	2	4	7	0	1	...
14992	dog	Fili	1	307	307	1	2	0	0	2	...

14993 rows × 28 columns

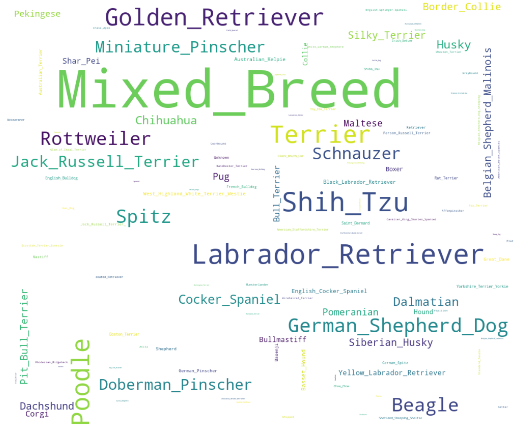
In [43]:

```
fig, ax = plt.subplots(figsize = (40, 36))
plt.subplot(2, 2, 1)
text_cat1 = ' '.join(data.loc[data['Type'] == 'cat', 'Breed1_name'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white', collocations=False,
                      width=1200, height=1000).generate(text_cat1)
plt.imshow(wordcloud)
plt.title('Top cat breed1', fontdict={'fontsize': 30})
plt.axis("off")

plt.subplot(2, 2, 2)
text_dog1 = ' '.join(data.loc[data['Type'] == 'dog', 'Breed1_name'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white', collocations=False,
                      width=1200, height=1000).generate(text_dog1)
plt.imshow(wordcloud)
plt.title('Top dog breed1', fontdict={'fontsize': 30})
plt.axis("off")

plt.subplot(2, 2, 3)
text_cat2 = ' '.join(data.loc[data['Type'] == 'cat', 'Breed2_name'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white', collocations=False,
                      width=1200, height=1000).generate(text_cat2)
plt.imshow(wordcloud)
plt.title('Top cat breed1', fontdict={'fontsize': 30})
plt.axis("off")

plt.subplot(2, 2, 4)
text_dog2 = ' '.join(data.loc[data['Type'] == 'dog', 'Breed2_name'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white', collocations=False,
                      width=1200, height=1000).generate(text_dog2)
plt.imshow(wordcloud)
plt.title('Top dog breed2', fontdict={'fontsize': 30})
plt.axis("off")
plt.show()
```

Top cat breed1

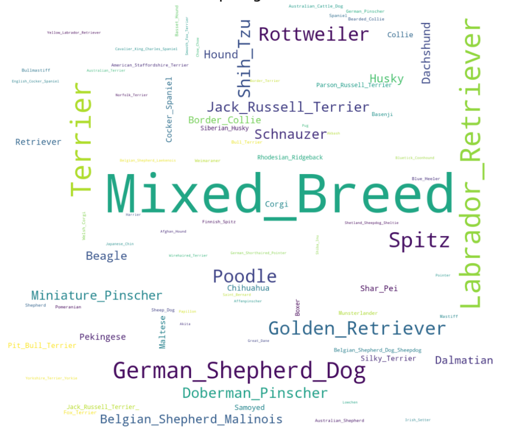


Top dog breed1



Top cat breed1

Top dog breed2



In [44]:

```
no_pure_breeds = ['Mixed_Breed', 'Domestic_Long_Hair', 'Domestic_Medium_Hair', 'Domestic_Sh

for x in no_pure_breeds:
    data.loc[data['Breed1_name'] == x, 'Pure_breed'] = 0
    data.loc[data['Breed2_name'] == x, 'Pure_breed'] = 0
```

In [45]:

```
print(f"Доля чистокровных животных = {round(data['Pure_breed'].sum()/len(data), 2)} %")
```

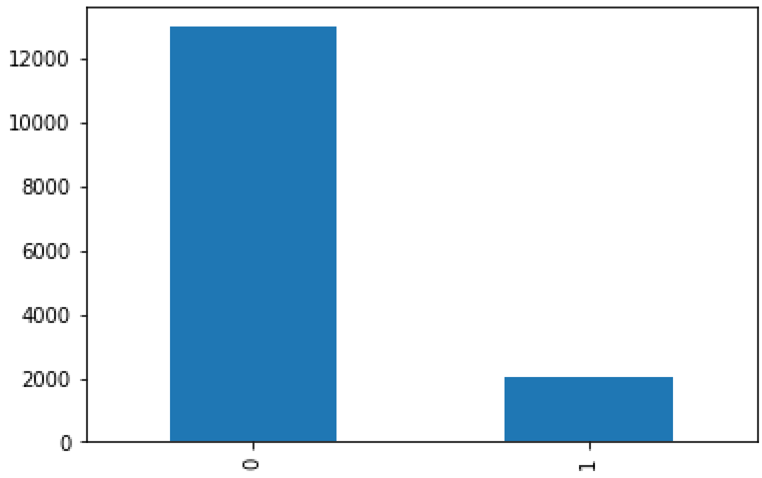
```
Доля чистокровных животных = 0.13 %
```

In [46]:

```
data['Pure_breed'].value_counts().plot.bar()
```

Out[46]:

```
<AxesSubplot:>
```



Пол

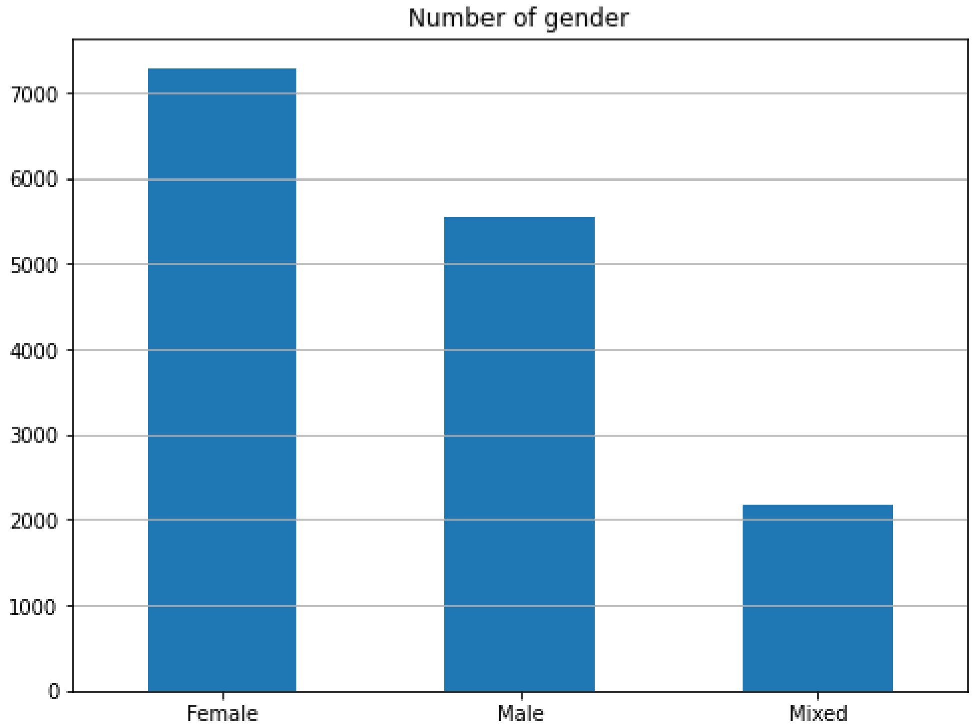
Пол питомца (1 = мужской, 2 = женский, 3 = смешанный, если в записи несколько животных)

In [47]:

```
graph_data = data['Gender'].apply(lambda x: 'Male' if x == 1 else ('Female' if x == 2 else
graph_data.value_counts().plot.bar(figsize=(8, 6), rot = 0)
plt.grid(axis='y')
plt.title('Number of gender')
```

Out[47]:

```
Text(0.5, 1.0, 'Number of gender')
```



In [48]:

```
graph_data.value_counts().to_frame("count")
```

Out[48]:

	count
Female	7277
Male	5536
Mixed	2180

Окрас

In [49]:

```
colors_dict = {k: v for k, v in zip(colors['ColorID'], colors['ColorName'])}
data['Color1_name'] = data['Color1'].apply(lambda x: colors_dict[x] if x in colors_dict els
data['Color2_name'] = data['Color2'].apply(lambda x: colors_dict[x] if x in colors_dict els
data['Color3_name'] = data['Color3'].apply(lambda x: colors_dict[x] if x in colors_dict els
colors_dict
```

Out[49]:

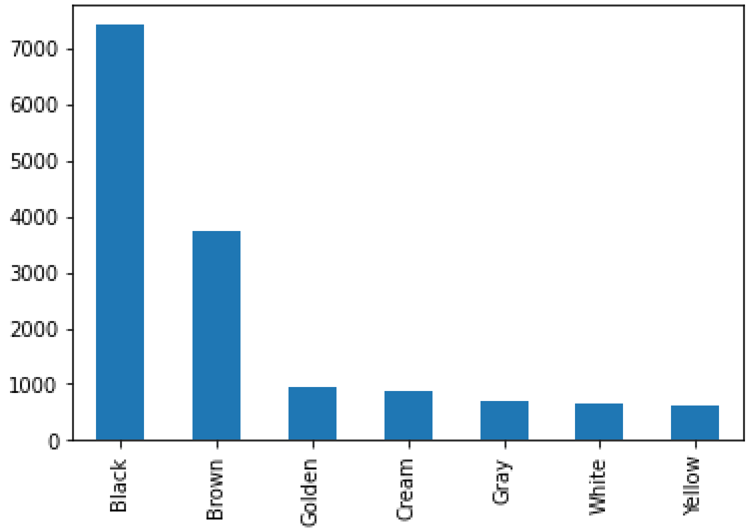
```
{1: 'Black',
 2: 'Brown',
 3: 'Golden',
 4: 'Yellow',
 5: 'Cream',
 6: 'Gray',
 7: 'White'}
```

In [50]:

```
data["Color1_name"].value_counts().plot.bar()
```

Out[50]:

<AxesSubplot:>

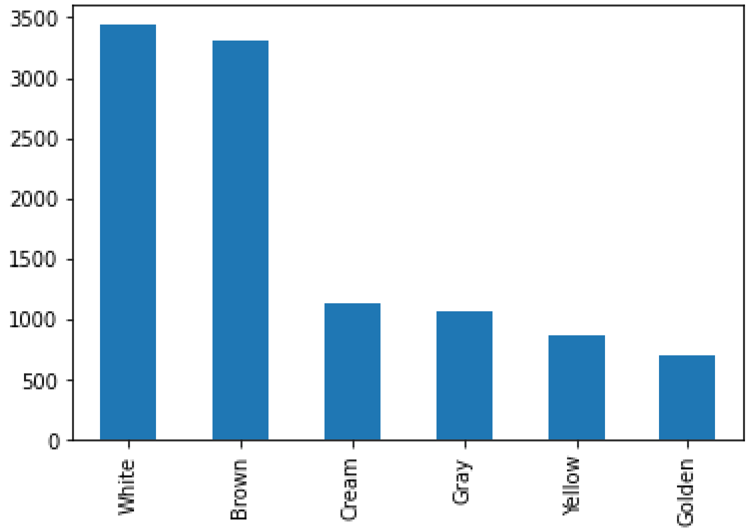


In [51]:

```
data["Color2_name"].value_counts().drop(index='').plot.bar()
```

Out[51]:

<AxesSubplot:>

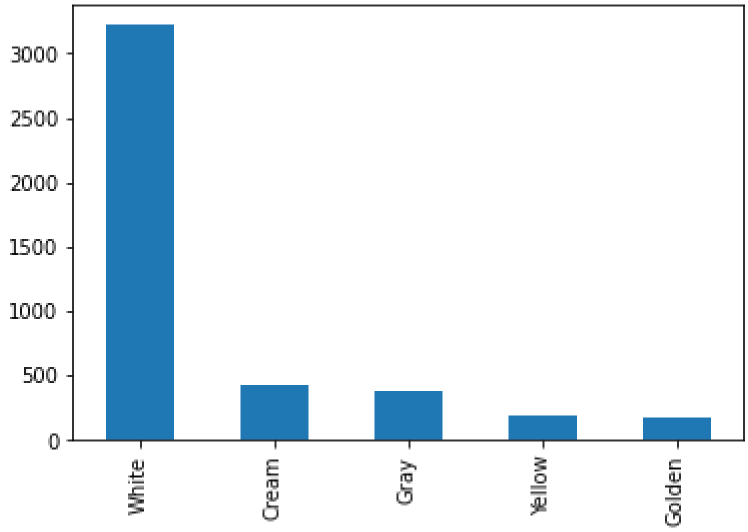


In [52]:

```
data["Color3_name"].value_counts().drop(index='').plot.bar()
```

Out[52]:

<AxesSubplot:>



In [53]:

```
data['full_color'] = (data['Color1_name'] + '__' + data['Color2_name'] + '__' + data['Color
```

In [54]:

```
data
```

Out[54]:

	Type	Name	Age	Breed1	Breed2	Gender	Color1	Color2	Color3	MaturitySize	...
0	cat	Nibble	3	299	0	1	1	7	0	1	...
1	cat	no_name	1	265	0	1	1	2	0	2	...
2	dog	Brisco	1	307	0	1	2	7	0	2	...
3	dog	Miko	4	307	0	2	1	2	0	2	...
4	dog	Hunter	1	307	0	1	1	0	0	2	...
...	...	...	...	...	...	...	...	...	...	...	...
14988	cat	no_name	2	266	0	3	1	0	0	2	...
14989	cat	Serato & Eddie	24	265	264	3	1	4	7	2	...
14990	cat	Monkies	2	265	266	3	5	6	7	3	...
14991	cat	Ms Daym	9	266	0	2	4	7	0	1	...
14992	dog	Fili	1	307	307	1	2	0	0	2	...

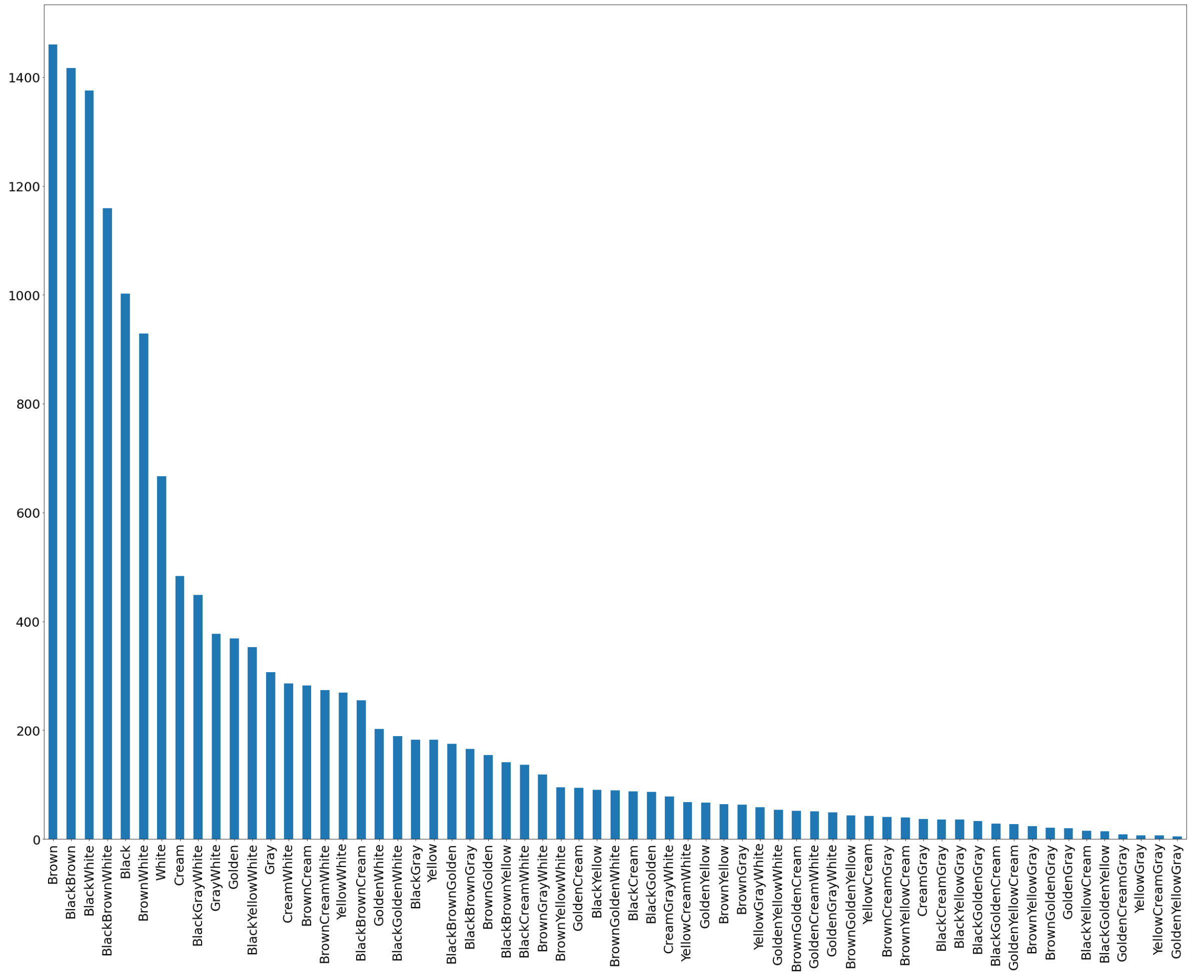
14993 rows × 32 columns

In [55]:

```
data["full_color"].value_counts().plot.bar(figsize = (40, 30), fontsize=25)
```

Out[55]:

<AxesSubplot:>

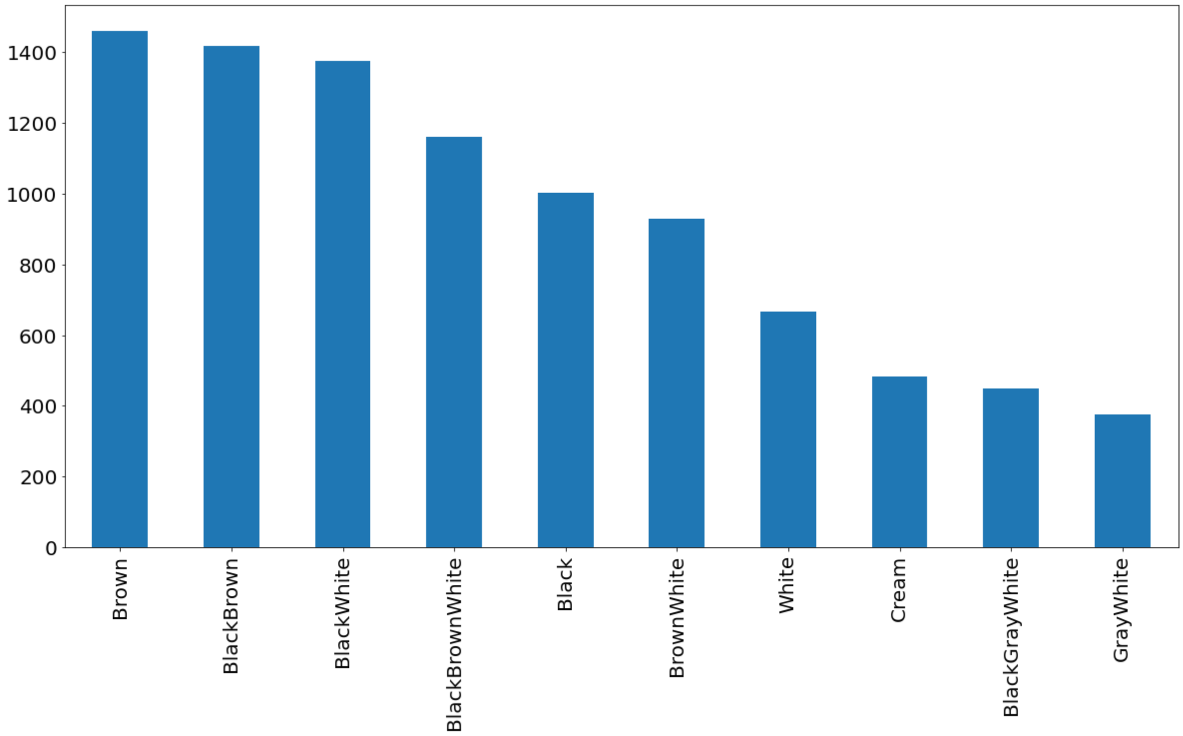


In [56]:

```
data["full_color"].value_counts()[:10].plot.bar(figsize = (20, 10), fontsize=20)
```

Out[56]:

```
<AxesSubplot:>
```



Размер животного в зрелом возрасте

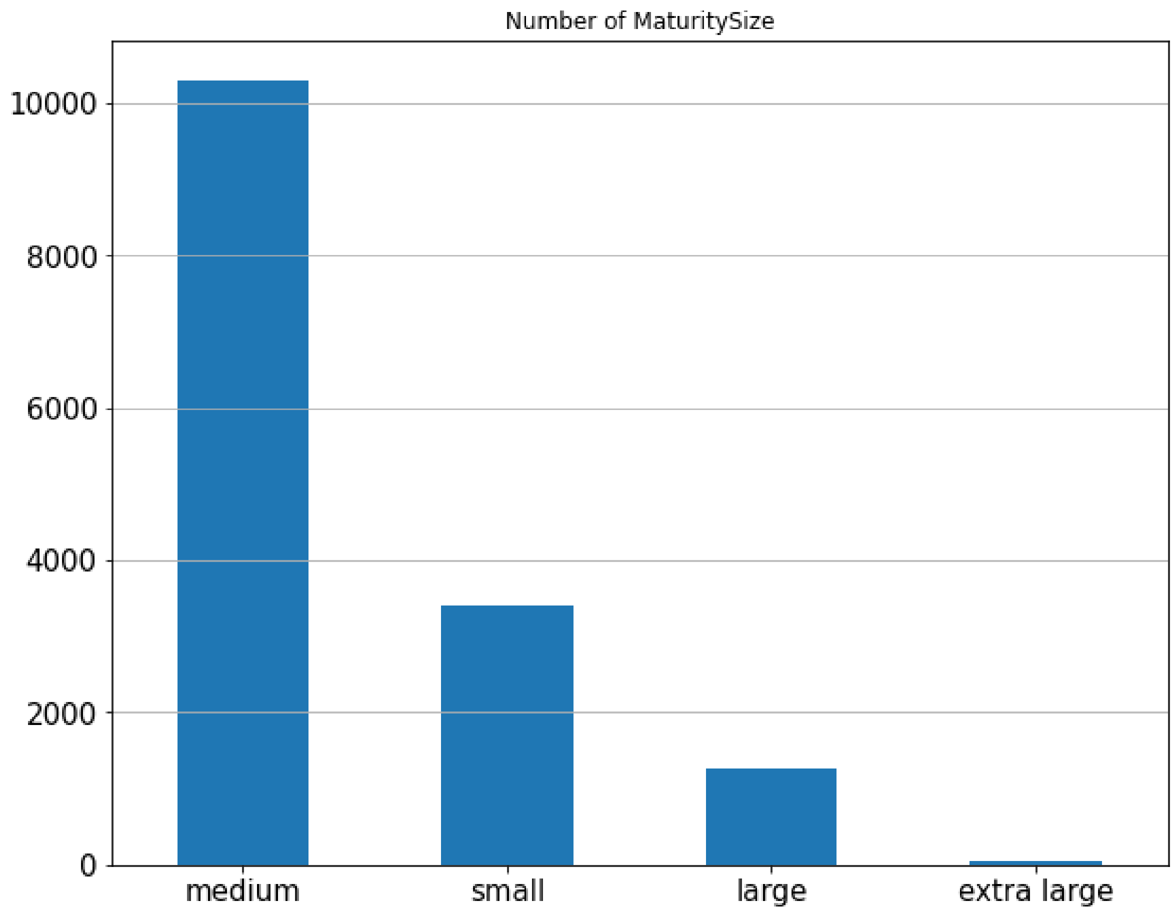
1 = маленький, 2 = средний, 3 = большой, 4 = очень большой, 0 = не указано

In [57]:

```
graph_data = data['MaturitySize'].apply(lambda x: 'small' if x == 1 else ('medium' if x ==
graph_data.value_counts().plot.bar(figsize=(10, 8), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title('Number of MaturitySize')
```

Out[57]:

```
Text(0.5, 1.0, 'Number of MaturitySize')
```

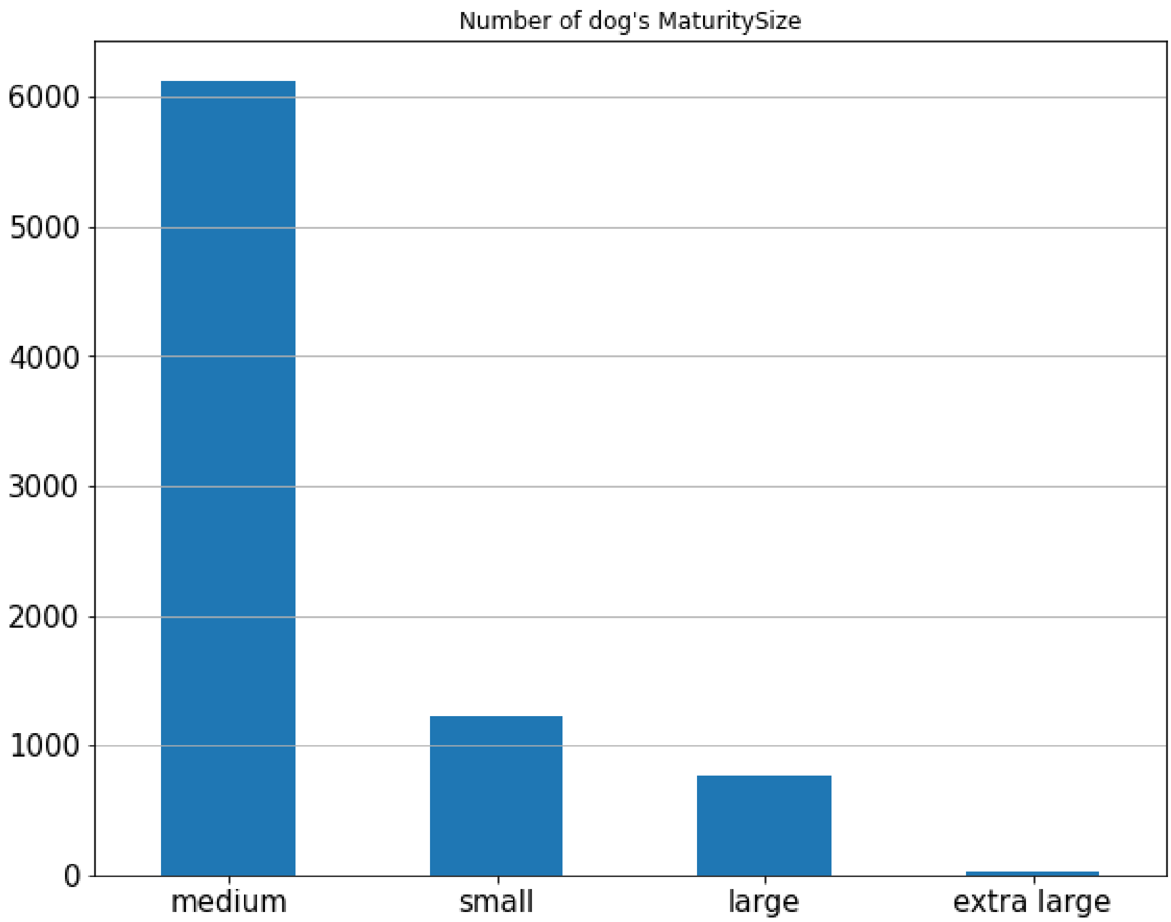


In [58]:

```
graph_data = data[data['Type'] == 'dog']['MaturitySize'].apply(lambda x: 'small' if x == 1
graph_data.value_counts().plot.bar(figsize=(10, 8), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title("Number of dog's MaturitySize")
```

Out[58]:

```
Text(0.5, 1.0, "Number of dog's MaturitySize")
```

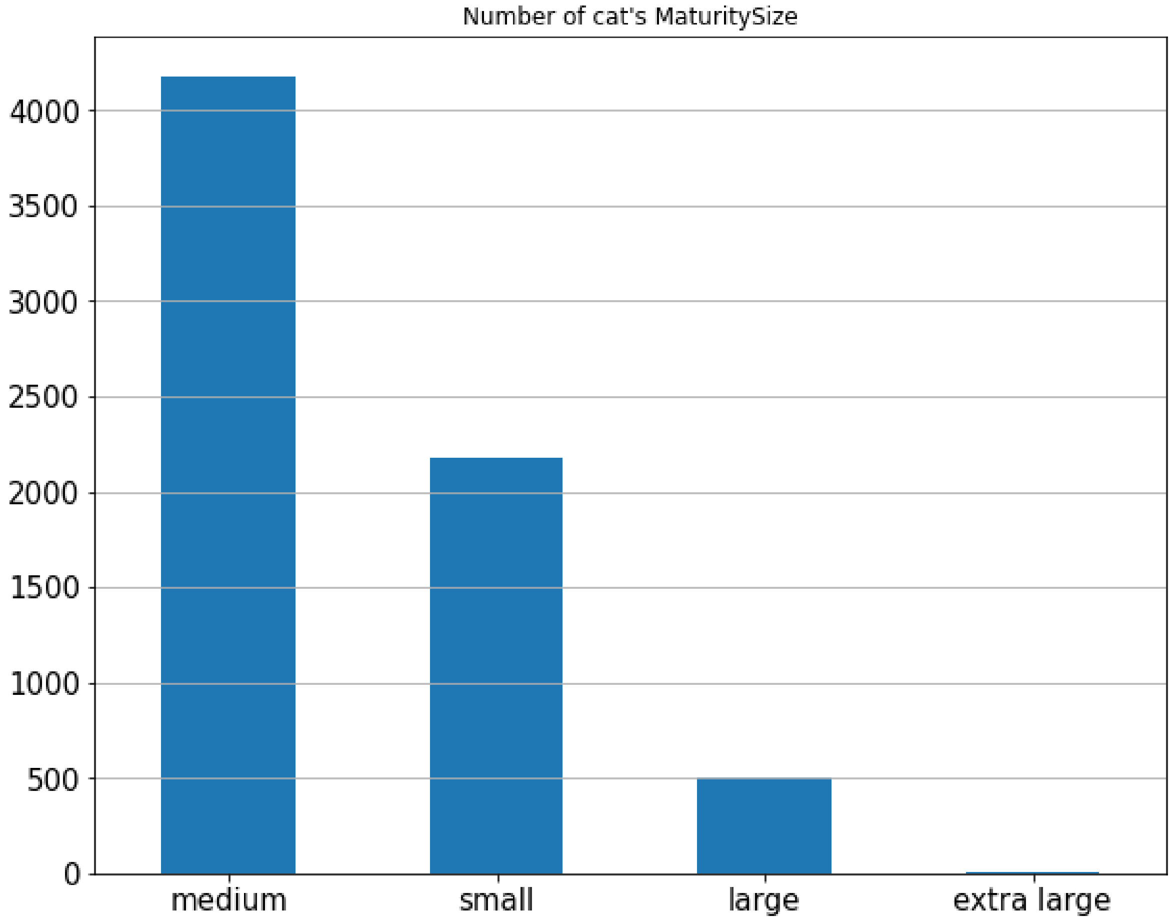


In [59]:

```
graph_data = data[data['Type'] == 'cat']['MaturitySize'].apply(lambda x: 'small' if x == 1
graph_data.value_counts().plot.bar(figsize=(10, 8), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title("Number of cat's MaturitySize")
```

Out[59]:

```
Text(0.5, 1.0, "Number of cat's MaturitySize")
```



Длина шерсти

1 = короткая, 2 = средняя, 3 = длинная, 0 = не указано

In [60]:

```
data["FurLength"].value_counts()
```

Out[60]:

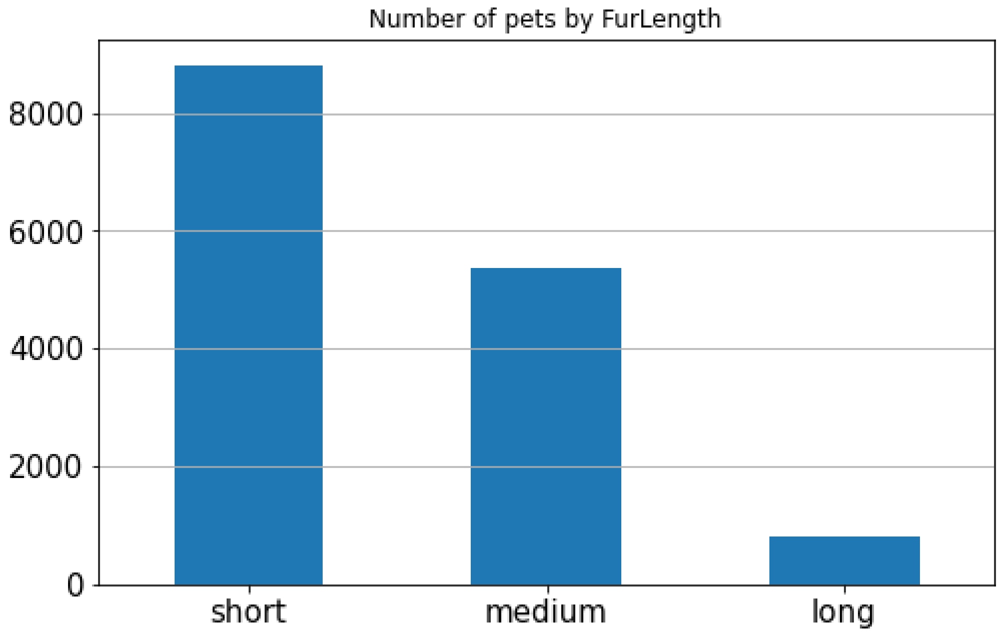
```
1    8808
2    5361
3     824
Name: FurLength, dtype: int64
```

In [61]:

```
graph_data = data['FurLength'].apply(lambda x: 'short' if x == 1 else ('medium' if x == 2 e
graph_data.value_counts().plot.bar(figsize=(8, 5), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title('Number of pets by FurLength')
```

Out[61]:

```
Text(0.5, 1.0, 'Number of pets by FurLength')
```



Здоровье

Есть 4 признака, относящиеся к здоровью питомца

- Vaccinated — вакцинировано ли домашнее животное (1 = да, 2 = нет, 3 = не уверены)
- Dewormed — избавлено ли животное от глистов (гельминтов) (1 = да, 2 = нет, 3 = не уверены)
- Sterilized — стерилизовано ли животное (1 = да, 2 = нет, 3 = не уверены)
- Health - состояние здоровья (1 = здоровый, 2 = легкая травма, 3 = серьезная травма)

In [62]:

```
data["Vaccinated"].value_counts()
```

Out[62]:

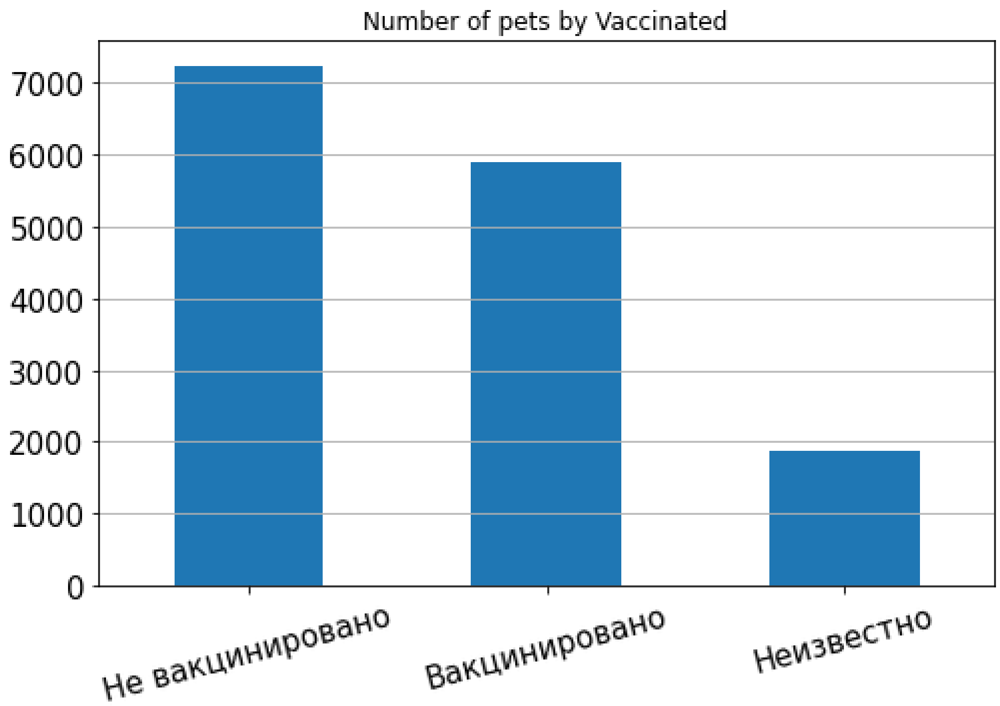
```
2    7227
1    5898
3    1868
Name: Vaccinated, dtype: int64
```

In [63]:

```
graph_data = data['Vaccinated'].apply(lambda x: 'Вакцинировано' if x == 1 else ('Не вакцини
graph_data.value_counts().plot.bar(figsize=(8, 5), rot = 15, fontsize=15)
plt.grid(axis='y')
plt.title('Number of pets by Vaccinated')
```

Out[63]:

```
Text(0.5, 1.0, 'Number of pets by Vaccinated')
```



In [64]:

```
data["Dewormed"].value_counts()
```

Out[64]:

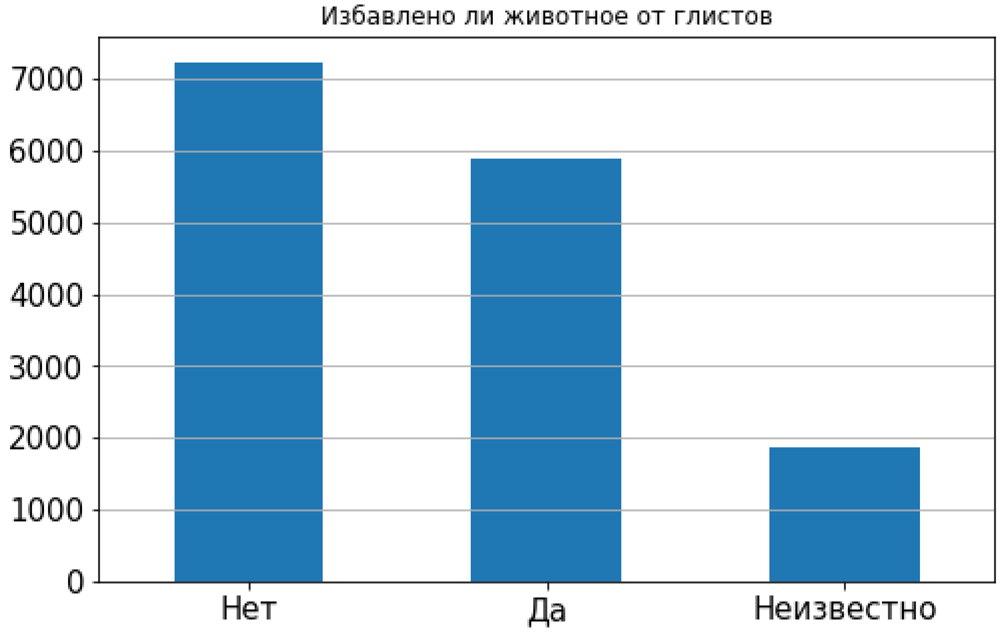
```
1    8397
2    4815
3    1781
Name: Dewormed, dtype: int64
```

In [65]:

```
graph_data = data['Vaccinated'].apply(lambda x: 'Да' if x == 1 else ('Нет' if x == 2 else '
graph_data.value_counts().plot.bar(figsize=(8, 5), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title('Избавлено ли животное от глистов')
```

Out[65]:

```
Text(0.5, 1.0, 'Избавлено ли животное от глистов')
```



In [66]:

```
data["Sterilized"].value_counts()
```

Out[66]:

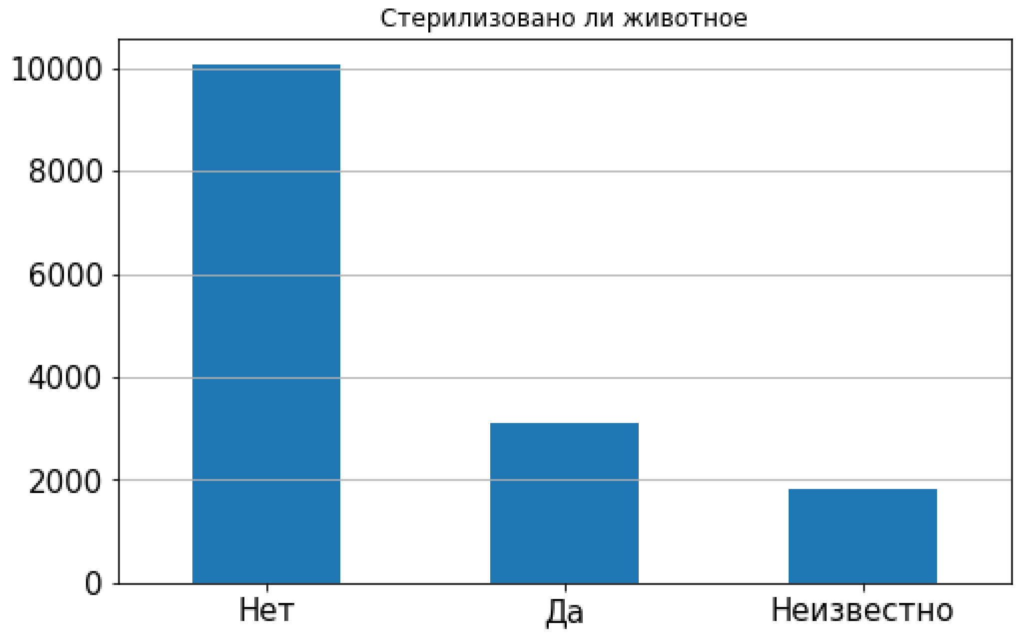
```
2    10077
1     3101
3     1815
Name: Sterilized, dtype: int64
```

In [67]:

```
graph_data = data['Sterilized'].apply(lambda x: 'Да' if x == 1 else ('Нет' if x == 2 else '
graph_data.value_counts().plot.bar(figsize=(8, 5), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title('Стерилизовано ли животное')
```

Out[67]:

```
Text(0.5, 1.0, 'Стерилизовано ли животное')
```



In [68]:

```
data["Health"].value_counts()
```

Out[68]:

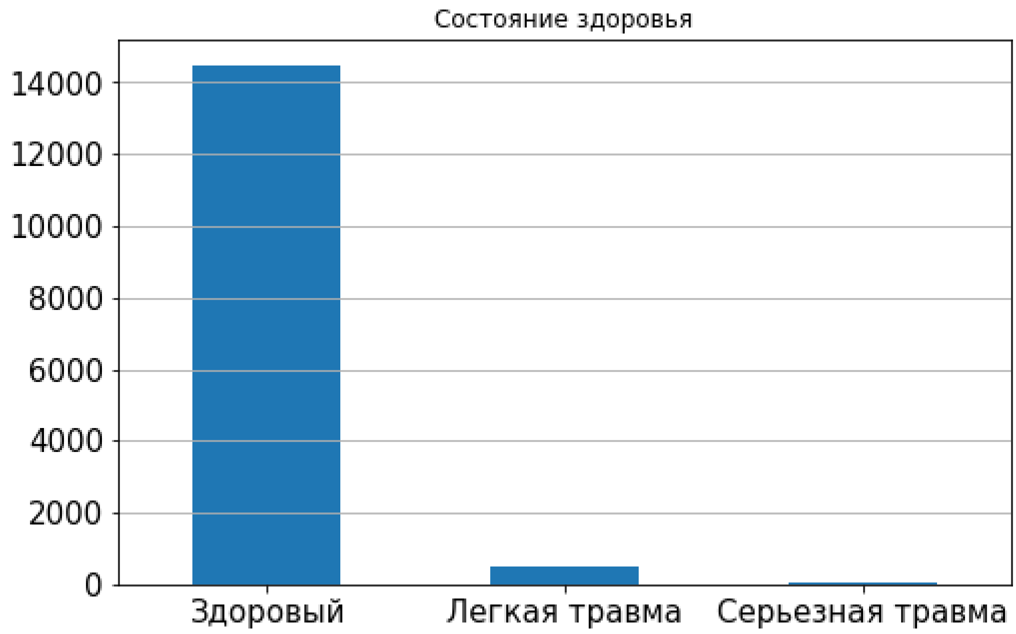
```
1    14478
2      481
3       34
Name: Health, dtype: int64
```

In [69]:

```
graph_data = data['Health'].apply(lambda x: 'Здоровый' if x == 1 else ('Легкая травма' if x
graph_data.value_counts().plot.bar(figsize=(8, 5), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title('Состояние здоровья')
```

Out[69]:

```
Text(0.5, 1.0, 'Состояние здоровья')
```

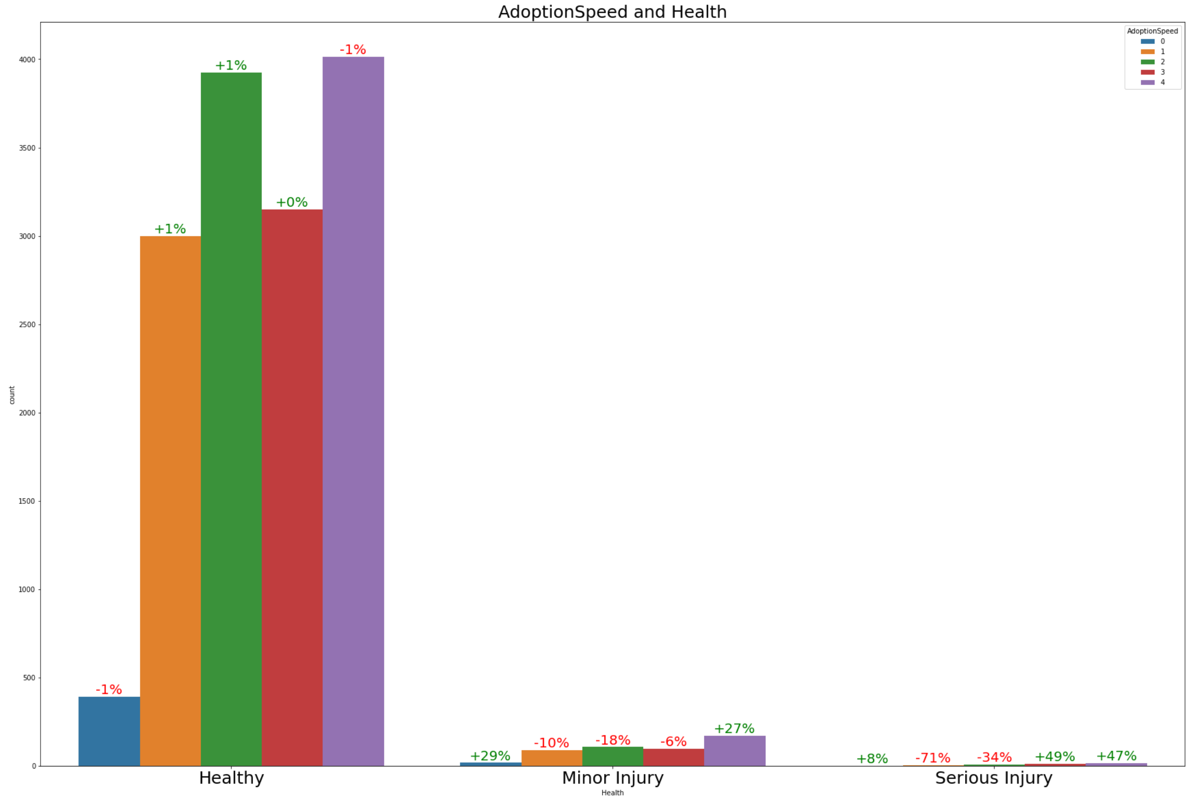


In [70]:

```
main_count = data['AdoptionSpeed'].value_counts(normalize=True).sort_index()

def prepare_plot_dict(df, col, main_count):
    """
    Preparing dictionary with data for plotting.

    I want to show how much higher/lower are the rates of Adoption speed for the current co
    At first I calculate base rates, then for each category in the column I calculate rates

    """
    main_count = dict(main_count)
    plot_dict = {}
    for i in df[col].unique():
        val_count = dict(df.loc[df[col] == i, 'AdoptionSpeed'].value_counts().sort_index())

        for k, v in main_count.items():
            if k in val_count:
                plot_dict[val_count[k]] = ((val_count[k] / sum(val_count.values())) / main_
            else:
                plot_dict[0] = 0

    return plot_dict

def make_count_plot(df, x, hue='AdoptionSpeed', title='', main_count=main_count):
    """
    Plotting countplot with correct annotations.
    """
    g = sns.countplot(x=x, data=df, hue=hue);
    plt.title(f'AdoptionSpeed {title}', fontsize=20);
    ax = g.axes

    plot_dict = prepare_plot_dict(df, x, main_count)

    for p in ax.patches:
        h = p.get_height() if str(p.get_height()) != 'nan' else 0
        text = f"{plot_dict[h]:.0f}%" if plot_dict[h] < 0 else f"+{plot_dict[h]:.0f}%"
        ax.annotate(text, (p.get_x() + p.get_width() / 2., h),
             ha='center', va='center', fontsize=20, color='green' if plot_dict[h] > 0 else
             textcoords='offset points')
```

In [71]:

```
plt.subplots(figsize=(30,20))
make_count_plot(df=data, x='Health', title='Health')
plt.xticks([0, 1, 2], ['Healthy', 'Minor Injury', 'Serious Injury'], fontsize=25);
plt.title('AdoptionSpeed and Health', fontsize=25);
```



In [72]:

```
data['full_health'] = data['Vaccinated'].astype(str) + '_' + data['Dewormed'].astype(str) +
data['full_health'].value_counts()[:5].plot.bar(figsize=(8, 5), rot = 0, fontsize=15)
plt.grid(axis='y')
plt.title('Самые популярные комбинации типов здоровья')
```

Out[72]:

```
Text(0.5, 1.0, 'Самые популярные комбинации типов здоровья')
```

- 1_1_1_1 — вакцинировано, избавлено от глистов, стерилизовано и здорово
- 1_1_2_1 — вакцинировано, избавлено от глистов, не стерилизовано и здорово
- 2_1_2_1 — не вакцинировано, избавлено от глистов, не стерилизовано и здорово
- 2_2_2_1 — не вакцинировано, не избавлено от глистов, не стерилизовано и здорово
- 3_3_3_1 — животное здорово, но информации о вакцинации, стерилизации и об избавлении от глистов нет

In [73]:

```
data['full_health'].value_counts()[:5]
```

Out[73]:

```
2_2_2_1    4189
1_1_2_1    2786
1_1_1_1    2377
2_1_2_1    2081
3_3_3_1     907
Name: full_health, dtype: int64
```

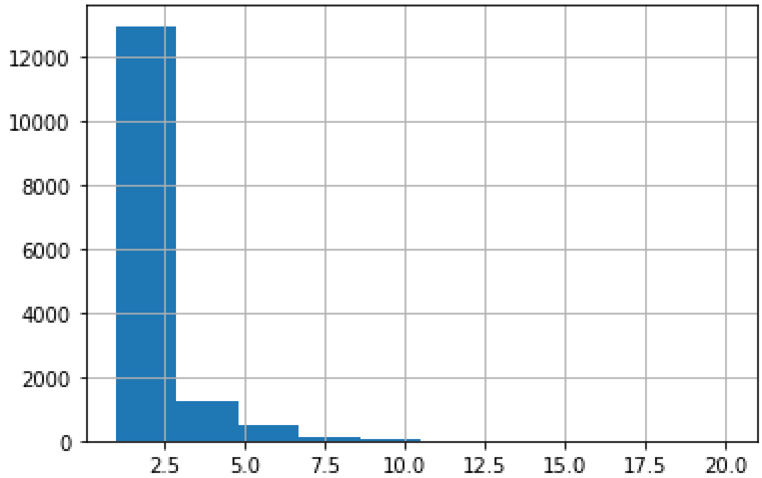
Количество животных в одном профиле

In [74]:

```
data['Quantity'].hist()
```

Out[74]:

```
<AxesSubplot:>
```



In [75]:

```
data['Quantity'].value_counts().sort_index()
```

Out[75]:

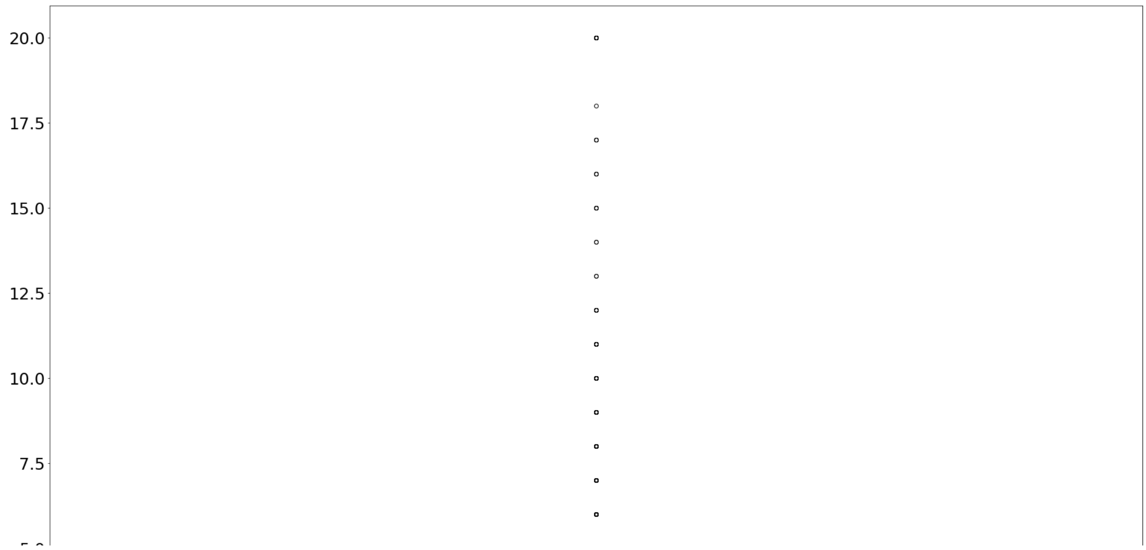
```
1     11565
2      1422
3       726
4       531
5       333
6       185
7        84
8        52
9        33
10       19
11       10
12        6
13        2
14        2
15        4
16        3
17        3
18        1
20       12
Name: Quantity, dtype: int64
```

In [76]:

```
data['Quantity'].plot.box(figsize = (30, 20), fontsize = 25)
```

Out[76]:

<AxesSubplot:>



In [77]:

```
data['one_pet'] = data["Quantity"].apply(lambda x: 1 if x==1  else 0)
```

Стоимость

Некоторых животных отдают бесплатно, а за некоторых требуют плату

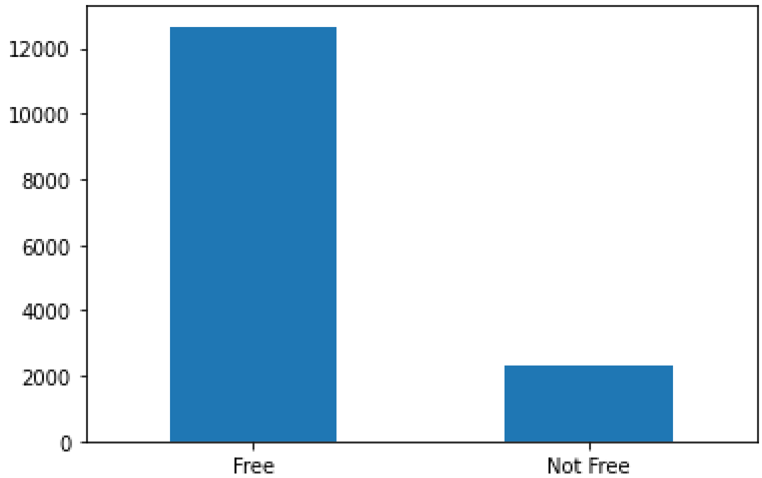
In [78]:

```
data['Free'] = data['Fee'].apply(lambda x: 'Free' if x == 0 else 'Not Free')
print(data["Free"].value_counts())
data["Free"].value_counts().plot.bar(rot = 0)
```

```
Free         12663
Not Free      2330
Name: Free, dtype: int64
```

Out[78]:

```
<AxesSubplot:>
```



In [79]:

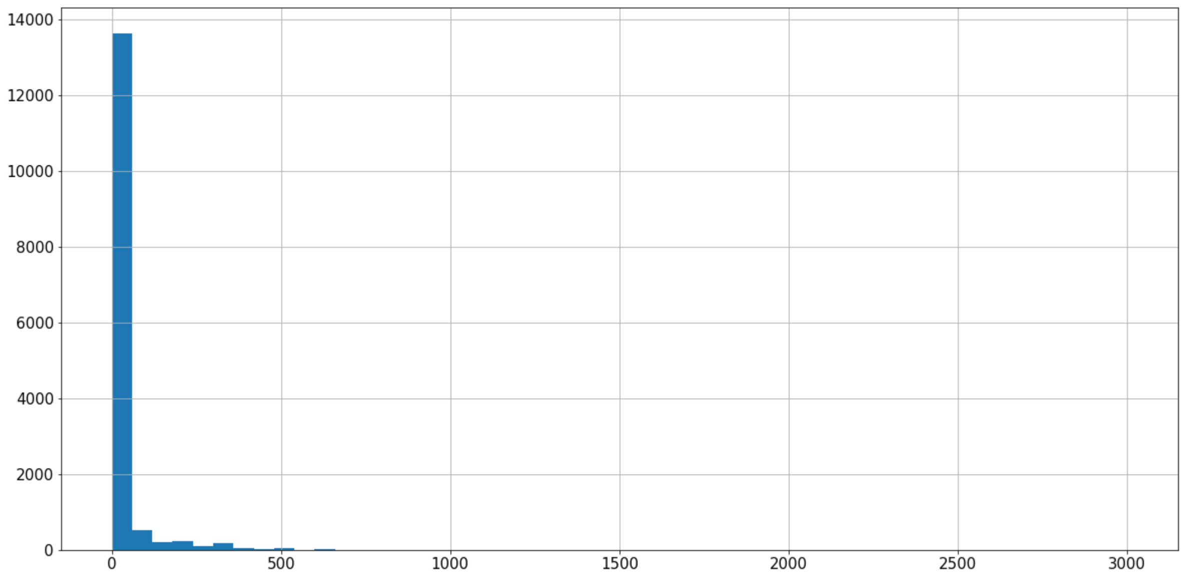
```
data['Free'] = data['Fee'].apply(lambda x: 1 if x == 0 else 0)
```

In [80]:

```
data['Fee'].hist(figsize = (20, 10), xlabelsize = 15, ylabelsize = 15, bins = 50)
```

Out[80]:

```
<AxesSubplot:>
```



In [81]:

```
data["Fee"].max()
```

Out[81]:

```
3000
```

In [82]:

```
data.sort_values('Fee', ascending=False)[['Name', 'Description', 'Fee', 'Breed1_name', 'Age
```

Out[82]:

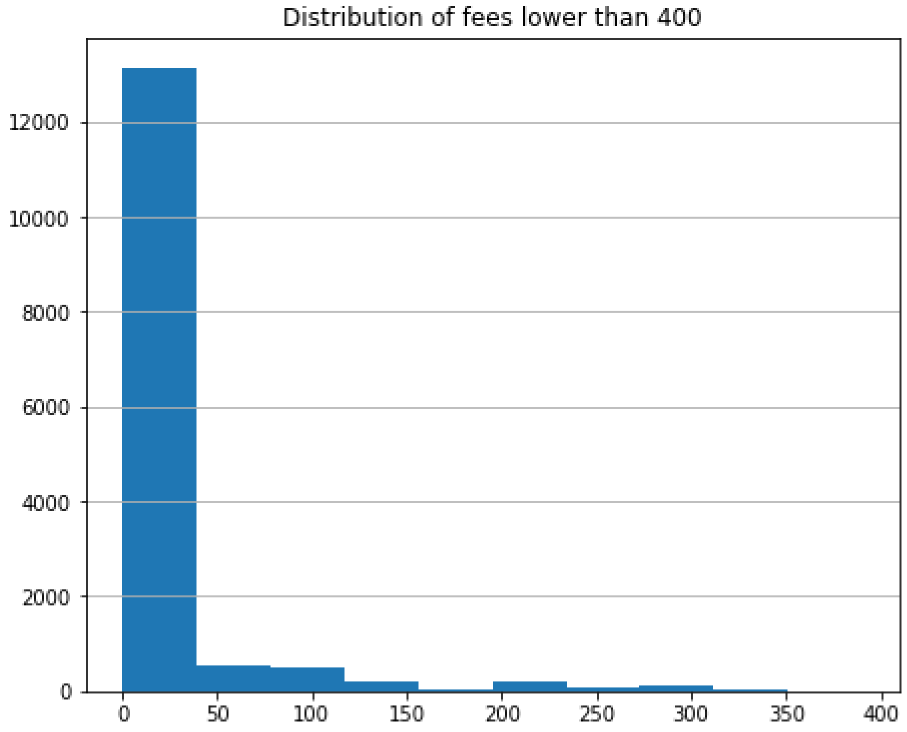
	Name	Description	Fee	Breed1_name	Age
8722	Khaleesi And Drogo	Both pups are family home trained. They love t...	3000	German_Shepherd_Dog	4
10477	Bull Dog	Found this bull dog near my neighbourhood for ...	2000	English_Bulldog	24
8879	Rottweiler Semi-Adult - Adoption	Looking for new lovely home due to owner lack ...	1000	Rottweiler	8
2078	Rottweiler - Adoption	Open for Adoption with Fees Looking for new lo...	1000	Rottweiler	8
8834	Adpoted	adpoted	1000	Shih_Tzu	24
4844	Coda	She is pure breed Siberian husky. Born at July...	1000	Siberian_Husky	7
9745	Oscar	Oscar was found in Ara Damansara recently. My ...	800	Rottweiler	24
9782	no_name	Available open for booking cute kitten Solid w...	800	Persian	1
14454	no_name	Looking for serius buyer Only female 2 month p...	750	Persian	2
11687	no_name	Open for adoption! They are a family of a set ...	750	Dilute_Tortoiseshell	12

In [83]:

```
plt.figure(figsize=(16, 6));
plt.subplot(1, 2, 1)
plt.hist(data.loc[data['Fee'] < 400, 'Fee'])
plt.grid(axis='y')
plt.title('Distribution of fees lower than 400')
```

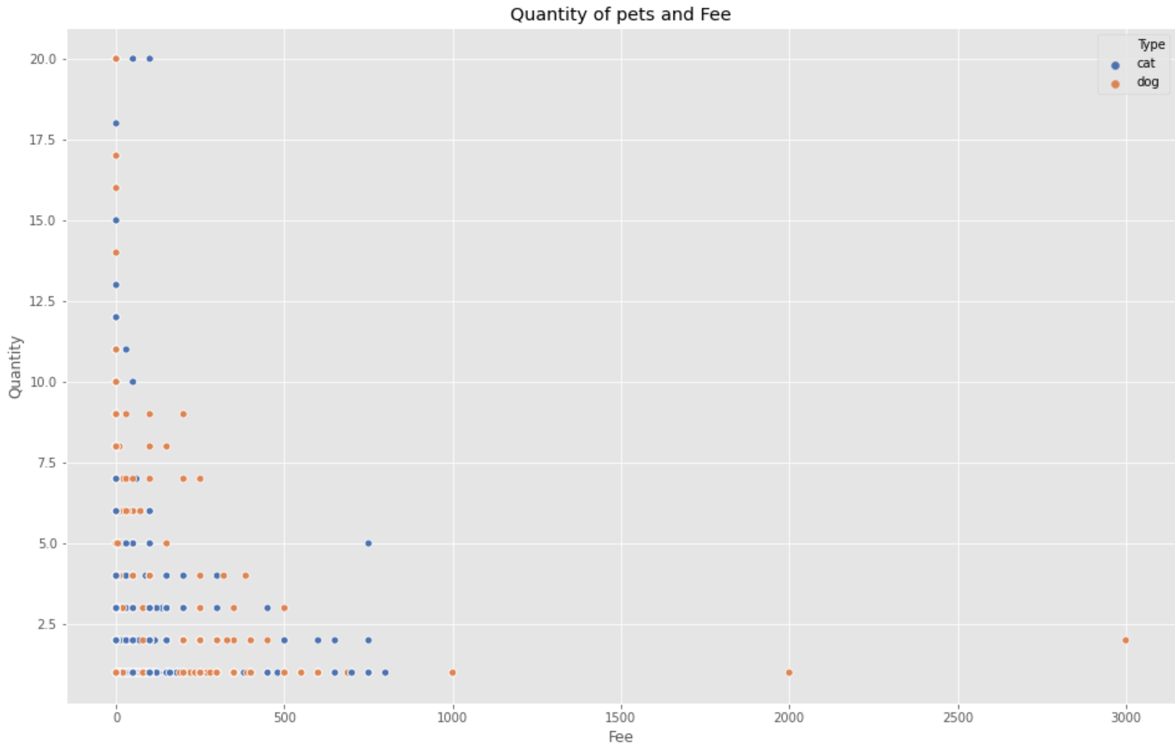
Out[83]:

```
Text(0.5, 1.0, 'Distribution of fees lower than 400')
```



In [84]:

```
plt.style.use('ggplot')
plt.figure(figsize=(16, 10));
sns.scatterplot(x="Fee", y="Quantity", hue="Type",data=data, palette = "deep");
plt.title('Quantity of pets and Fee');
```

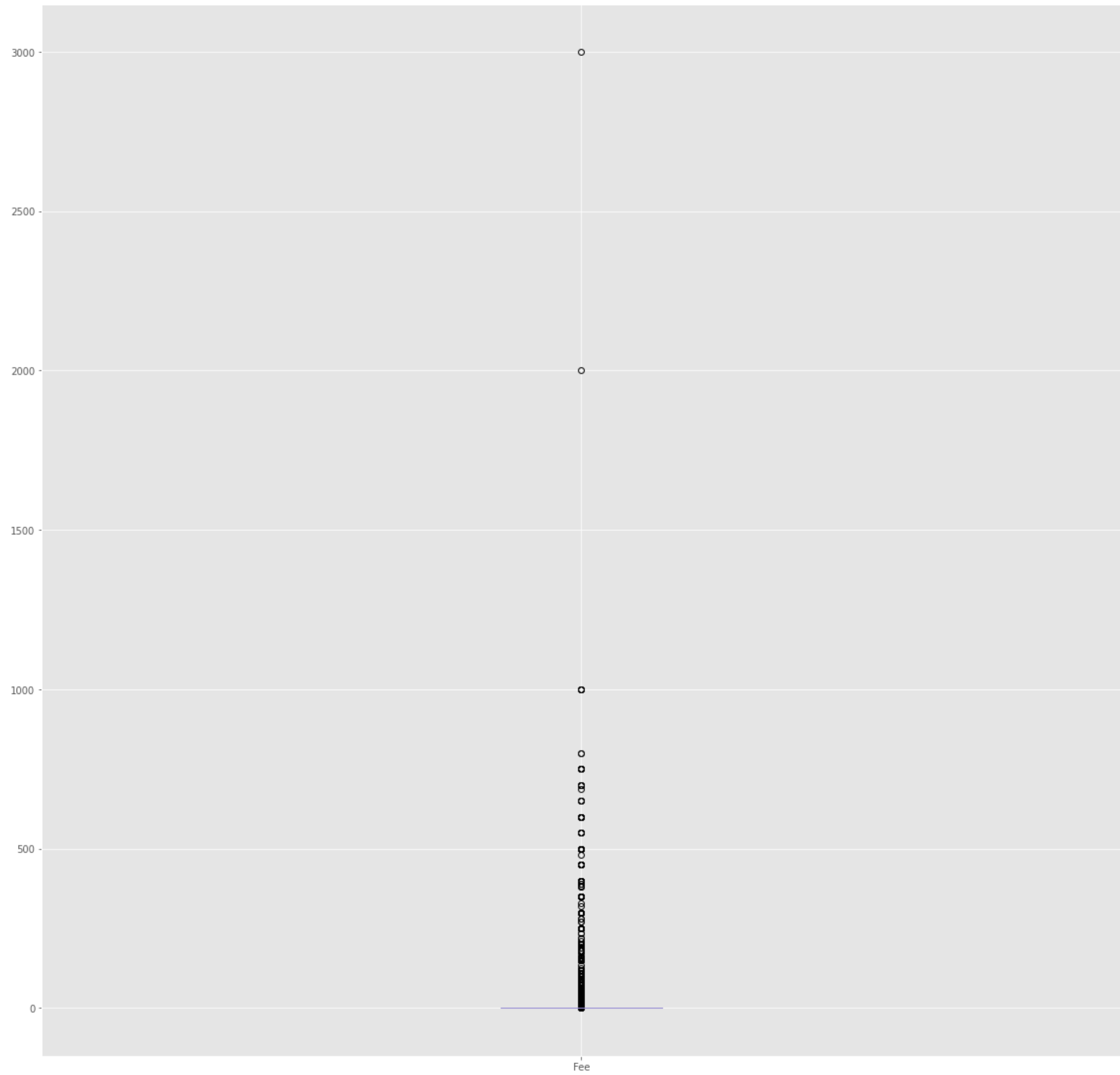


In [85]:

```
data["Fee"].plot.box(figsize=(20,20))
# Что делать в этом случае?
```

Out[85]:

```
<AxesSubplot:>
```

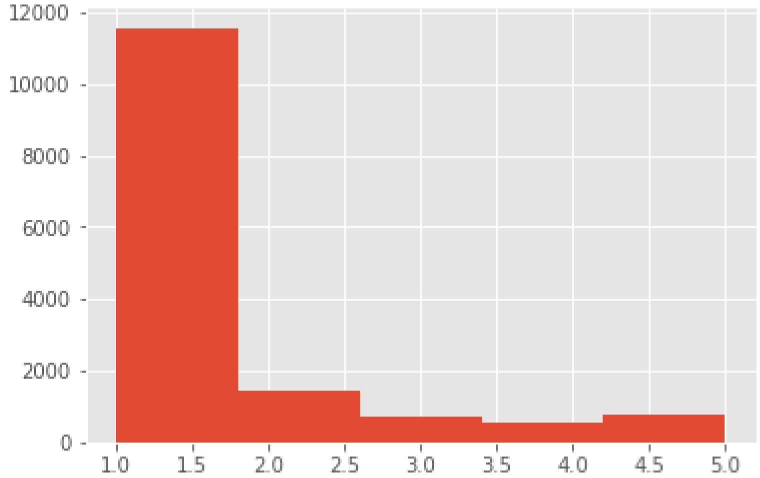


In [86]:

```
data["Quantity"] = data["Quantity"].apply(lambda x: x if x <= 5 else 5)
data["Fee"] = data["Fee"].apply(lambda x: x if x <= 500 else 500)
data["Quantity"].hist(bins=5)
```

Out[86]:

<AxesSubplot:>

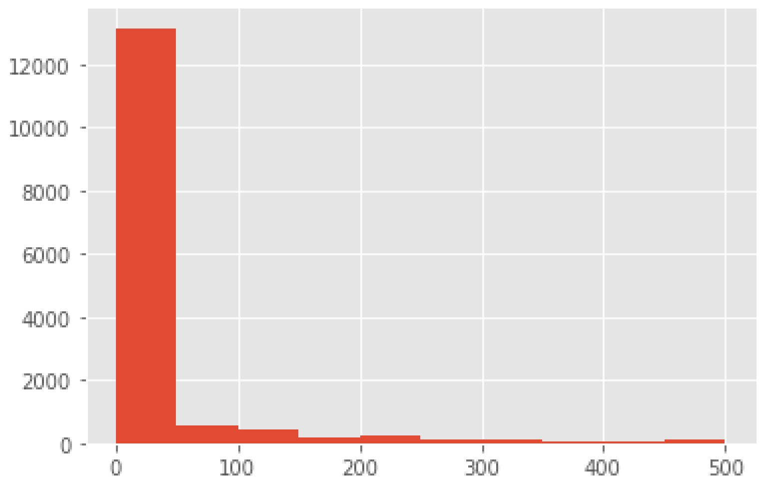


In [87]:

```
data["Fee"].hist()
```

Out[87]:

<AxesSubplot:>



Месторасположение

In [88]:

```
data["State"].value_counts()
```

Out[88]:

```
41326    8714
41401    3845
41327     843
41336     507
41330     420
41332     253
41324     137
41325     110
41335      85
41361      26
41345      22
41367      15
41342      13
41415       3
Name: State, dtype: int64
```

In [89]:

```
states_dict = {k: v for k, v in zip(states['StateID'], states['StateName'])}
states_dict
```

Out[89]:

```
{41336: 'Johor',
 41325: 'Kedah',
 41367: 'Kelantan',
 41401: 'Kuala Lumpur',
 41415: 'Labuan',
 41324: 'Melaka',
 41332: 'Negeri Sembilan',
 41335: 'Pahang',
 41330: 'Perak',
 41380: 'Perlis',
 41327: 'Pulau Pinang',
 41345: 'Sabah',
 41342: 'Sarawak',
 41326: 'Selangor',
 41361: 'Terengganu'}
```

In [90]:

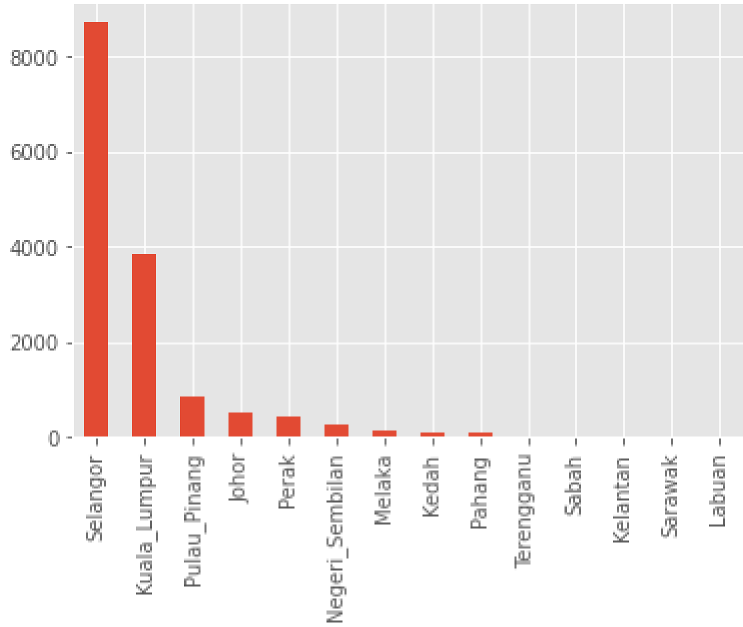
```
data['State_name'] = data['State'].apply(lambda x: '_'.join(states_dict[x].split()) if x in
```

In [91]:

```
data['State_name'].value_counts().plot.bar()
```

Out[91]:

```
<AxesSubplot:>
```



In [92]:

```
data['State_name'].value_counts()
```

Out[92]:

```
Selangor           8714
Kuala_Lumpur       3845
Pulau_Pinang        843
Johor               507
Perak               420
Negeri_Sembilan     253
Melaka              137
Kedah               110
Pahang               85
Terengganu           26
Sabah                22
Kelantan             15
Sarawak              13
Labuan                3
Name: State_name, dtype: int64
```

In [93]:

```
print(data['State_name'].value_counts(normalize=True).head(6).sum())
data['State_name'].value_counts(normalize=True).head(6)
```

```
0.9725872073634363
```

Out[93]:

```
Selangor           0.581205
Kuala_Lumpur       0.256453
Pulau_Pinang       0.056226
Johor              0.033816
Perak              0.028013
Negeri_Sembilan    0.016875
Name: State_name, dtype: float64
```

In [94]:

```
data.shape
14993*0.9725872073634363
```

Out[94]:

```
14582.0
```

In [95]:

```
state_in = ['Selangor', 'Kuala_Lumpur', 'Pulau_Pinang', 'Johor', 'Perak', 'Negeri_Sembilan'
data["State_name"] = data["State_name"].apply(lambda x: np.nan if x not in state_in else x)
```

In [96]:

```
data.dropna(inplace=True)
```

In [97]:

```
data.shape
```

Out[97]:

```
(14582, 36)
```

In [98]:

```
data['State_name'].value_counts()
```

Out[98]:

```
Selangor           8714
Kuala_Lumpur       3845
Pulau_Pinang        843
Johor               507
Perak               420
Negeri_Sembilan     253
Name: State_name, dtype: int64
```

ID тех, кто отдаёт питомцев

In [99]:

```
data["RescuerID"].value_counts()
```

Out[99]:

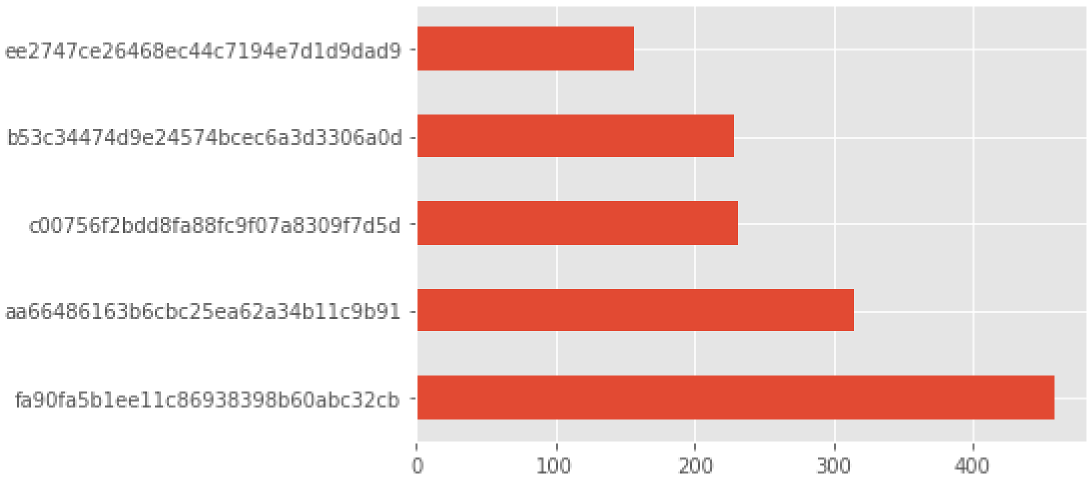
```
fa90fa5b1ee11c86938398b60abc32cb    459
aa66486163b6cbc25ea62a34b11c9b91    315
c00756f2bdd8fa88fc9f07a8309f7d5d    231
b53c34474d9e24574bcec6a3d3306a0d    228
ee2747ce26468ec44c7194e7d1d9dad9    156
                                   ...
22414cc92d4bbd1571fa0cd246cb591b      1
93f135ddaf72b4ed1b60521fdeab9426      1
e928450b5c3ee09ec5c378459a043916      1
566ba0fd7393d94d0a98df0354be3b5c      1
7e1b8f045013ae6e1cd40f5cca103d9f      1
Name: RescuerID, Length: 5415, dtype: int64
```

In [100]:

```
data["RescuerID"].value_counts().head().plot.barh()
```

Out[100]:

<AxesSubplot:>



In [101]:

```
st = set(data["RescuerID"].value_counts().values)
dict_resc = dict(data["RescuerID"].value_counts())
st = list(st)
st.sort(reverse=True)
dict_rank = dict()
i = 1
for x in st:
    dict_rank[x] = i
    i += 1
data["RankRescuer"] = data["RescuerID"].apply(lambda x: dict_rank[dict_resc[x]])
```

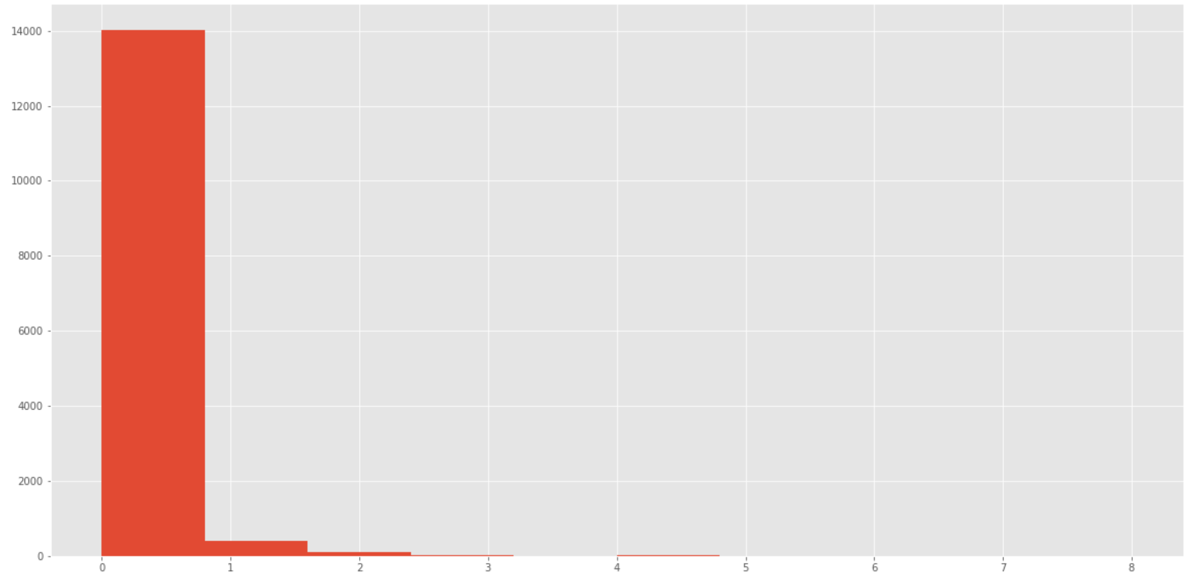
Количество видео

In [102]:

```
data['VideoAmt'].hist(figsize=(20,10))
```

Out[102]:

```
<AxesSubplot:>
```



In [103]:

```
data["VideoAmt"].value_counts(normalize=True)
```

Out[103]:

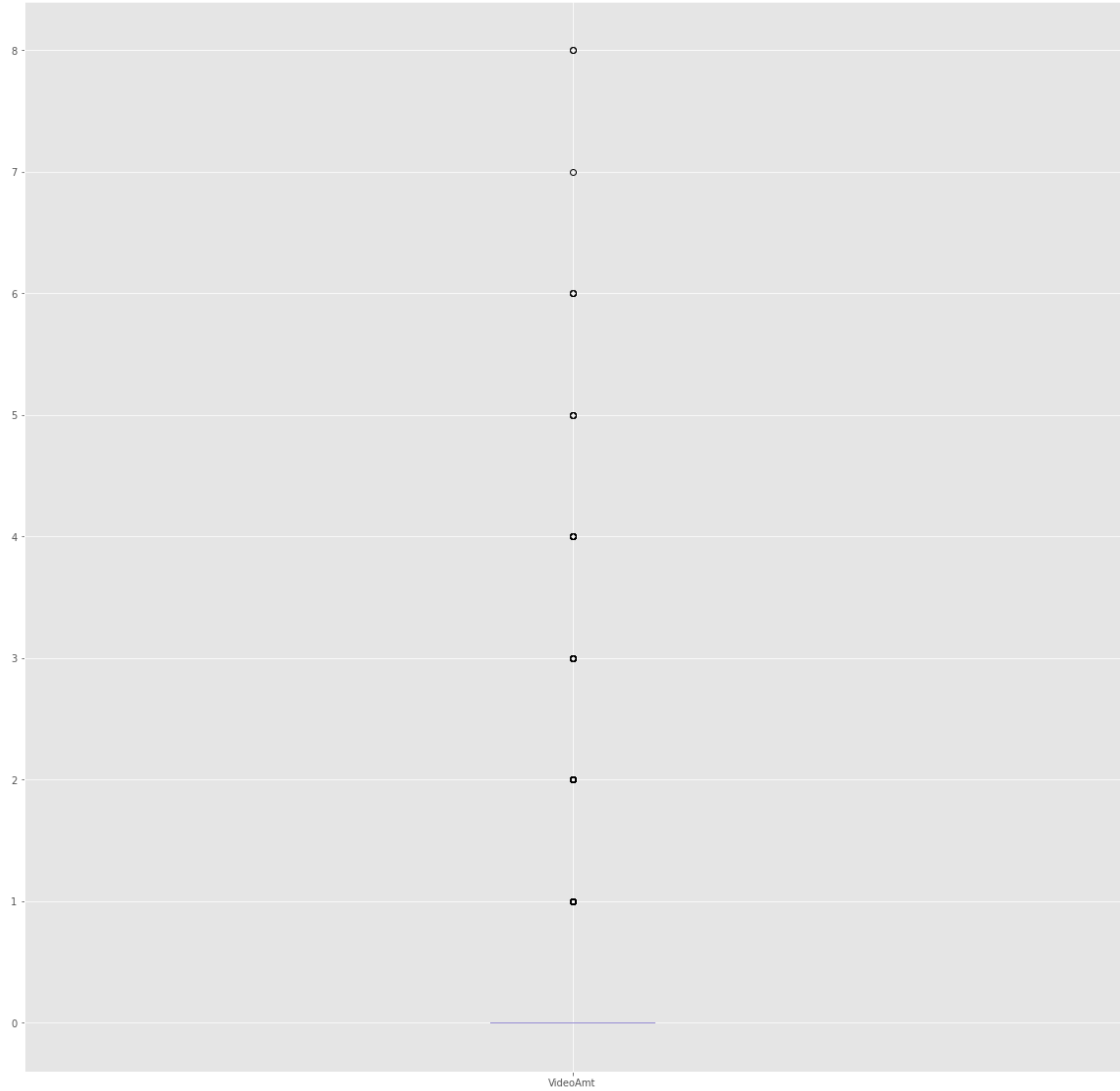
```
0    0.961185
1    0.028323
2    0.006241
3    0.002400
4    0.001029
5    0.000343
6    0.000274
8    0.000137
7    0.000069
Name: VideoAmt, dtype: float64
```

In [104]:

```
data["VideoAmt"].plot.box(figsize=(20,20))
```

Out[104]:

<AxesSubplot:>



In [105]:

```
data["has_video"] = data["VideoAmt"].apply(lambda x: 1 if x > 0 else 0)
data[data["has_video"] == 1][["VideoAmt", "has_video"]]
```

Out[105]:

	VideoAmt	has_video
76	1	1
88	3	1
89	4	1
125	1	1
153	1	1
...	...	...
14892	1	1
14897	2	1
14950	1	1
14960	1	1
14966	1	1

566 rows × 2 columns

Количество фото

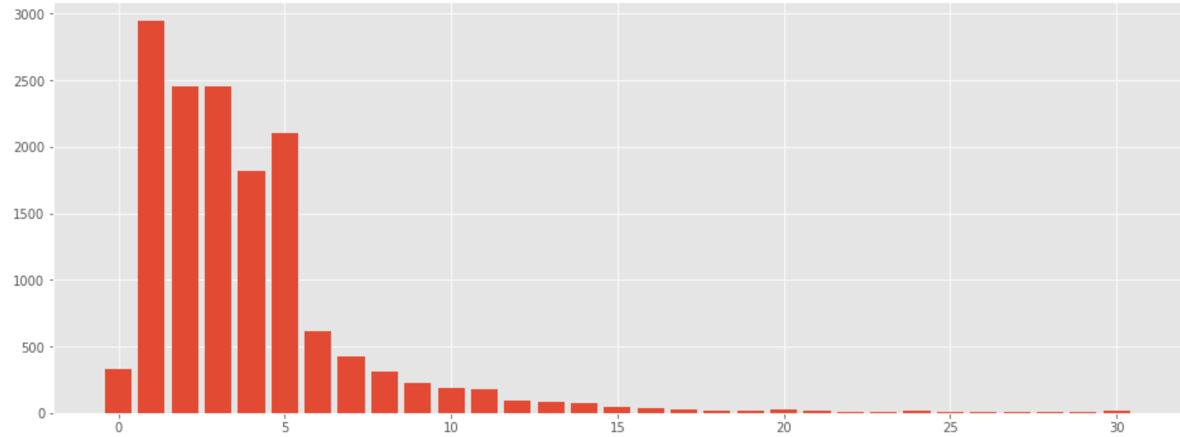
In [106]:

```
print(F'Maximum amount of photos in {data["PhotoAmt"].max()}')
```

```
Maximum amount of photos in 30.0
```

In [107]:

```
index = range(0, 31)
values = data['PhotoAmt'].value_counts().sort_index().to_numpy()
plt.figure(figsize=(16, 6));
plt.bar(index,values)
plt.show()
```



In [108]:

```
data["PhotoAmt"].plot.box(figsize=(20,20))
```

Out[108]:

```
<AxesSubplot:>
```

In [109]:

```
index,para = outlier_detect_IQR(data=data,col='PhotoAmt',threshold=1)
print('Верхняя граница:',para[0],'\nНижняя граница:',para[1])
```

```
Количество выбросов в данных: 1131
Доля выбросов: 0.07756137704018654
Верхняя граница: 8.0
Нижняя граница: -1.0
```

In [110]:

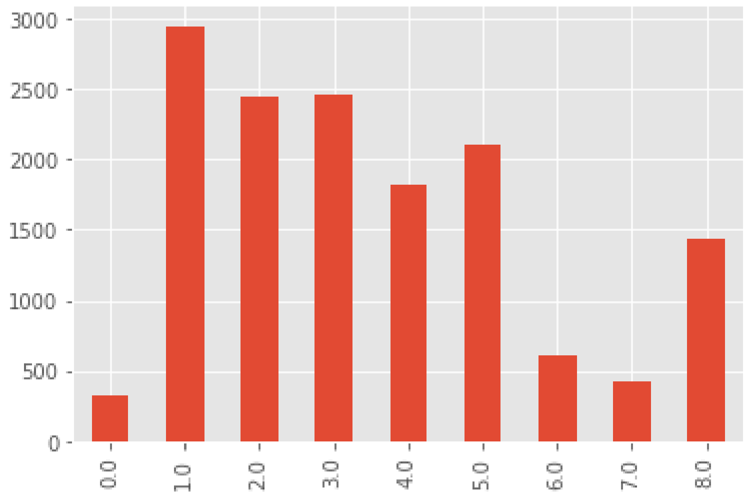
```
data = impute_outlier_with_arbitrary(data=data,outlier_index=index, value= 8, col=['PhotoAm
```

In [111]:

```
data['PhotoAmt'].value_counts().sort_index().plot.bar()
```

Out[111]:

<AxesSubplot:>

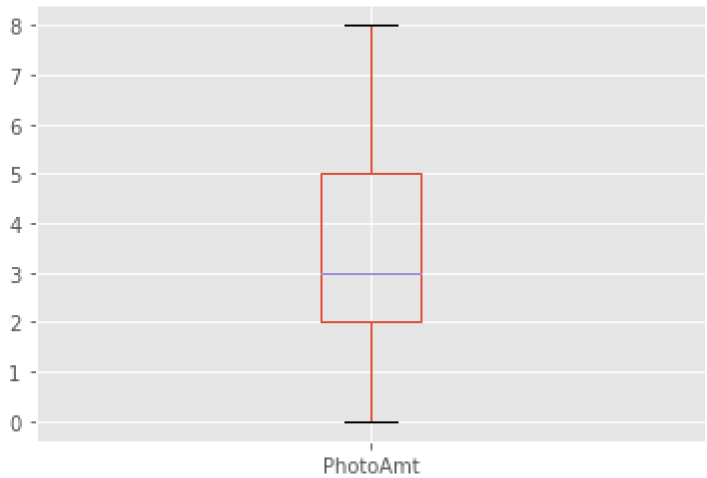


In [112]:

```
data['PhotoAmt'].plot.box()
```

Out[112]:

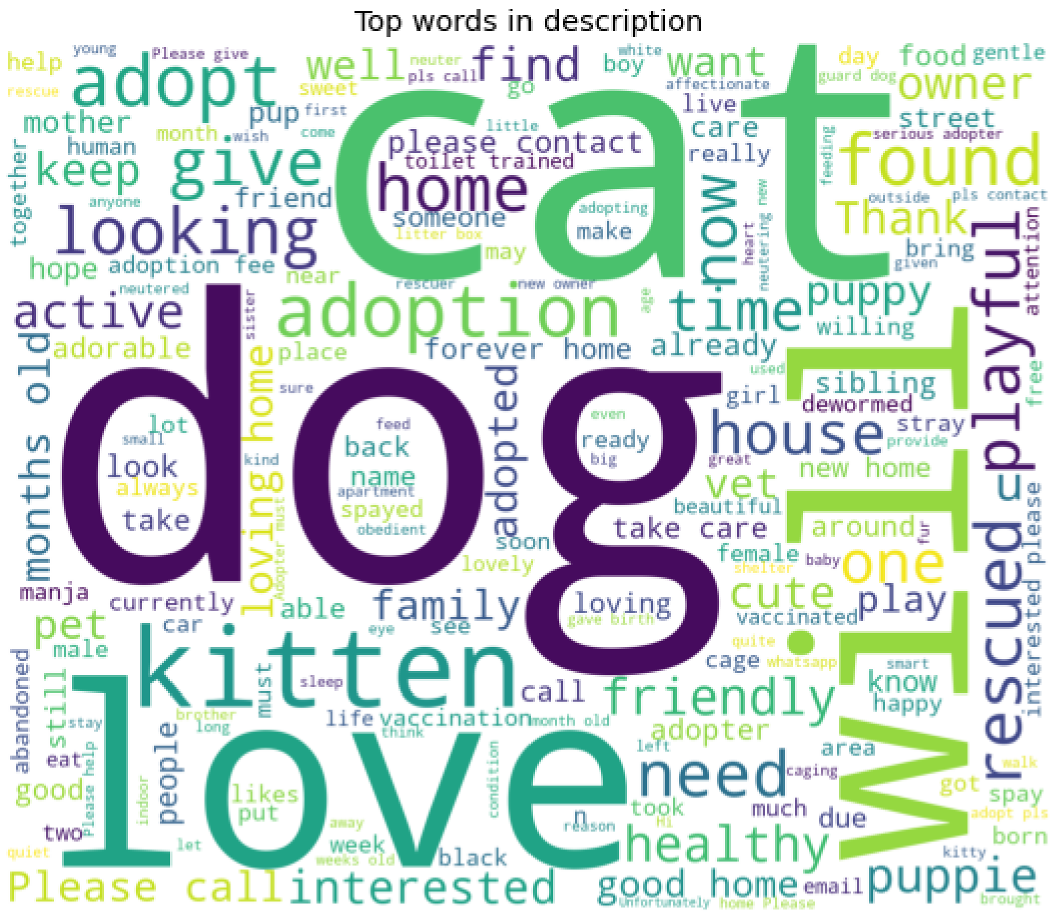
<AxesSubplot:>



Описание

In [113]:

```
fig, ax = plt.subplots(figsize = (12, 8))
text_cat = ' '.join(data['Description'].fillna('').values)
wordcloud = WordCloud(max_font_size=None, background_color='white',
                      width=1200, height=1000).generate(text_cat)
plt.imshow(wordcloud)
plt.title('Top words in description');
plt.axis("off");
```



In [103]:

```
sentiment_dict = {}
for filename in os.listdir('../petfinder/train_sentiment/'):
    with open('../petfinder/train_sentiment/' + filename, 'r', errors='ignore') as f:
        sentiment = json.load(f)
    pet_id = filename.split('.')[0]
    sentiment_dict[pet_id] = {}
    sentiment_dict[pet_id]['magnitude'] = sentiment['documentSentiment']['magnitude']
    sentiment_dict[pet_id]['score'] = sentiment['documentSentiment']['score']
    sentiment_dict[pet_id]['language'] = sentiment['language']
```

In [104]:

```
data['lang'] = data['PetID'].apply(lambda x: sentiment_dict[x]['language'] if x in sentimen
data['magnitude'] = data['PetID'].apply(lambda x: sentiment_dict[x]['magnitude'] if x in se
data['score'] = data['PetID'].apply(lambda x: sentiment_dict[x]['score'] if x in sentiment_
data
```

Out[104]:

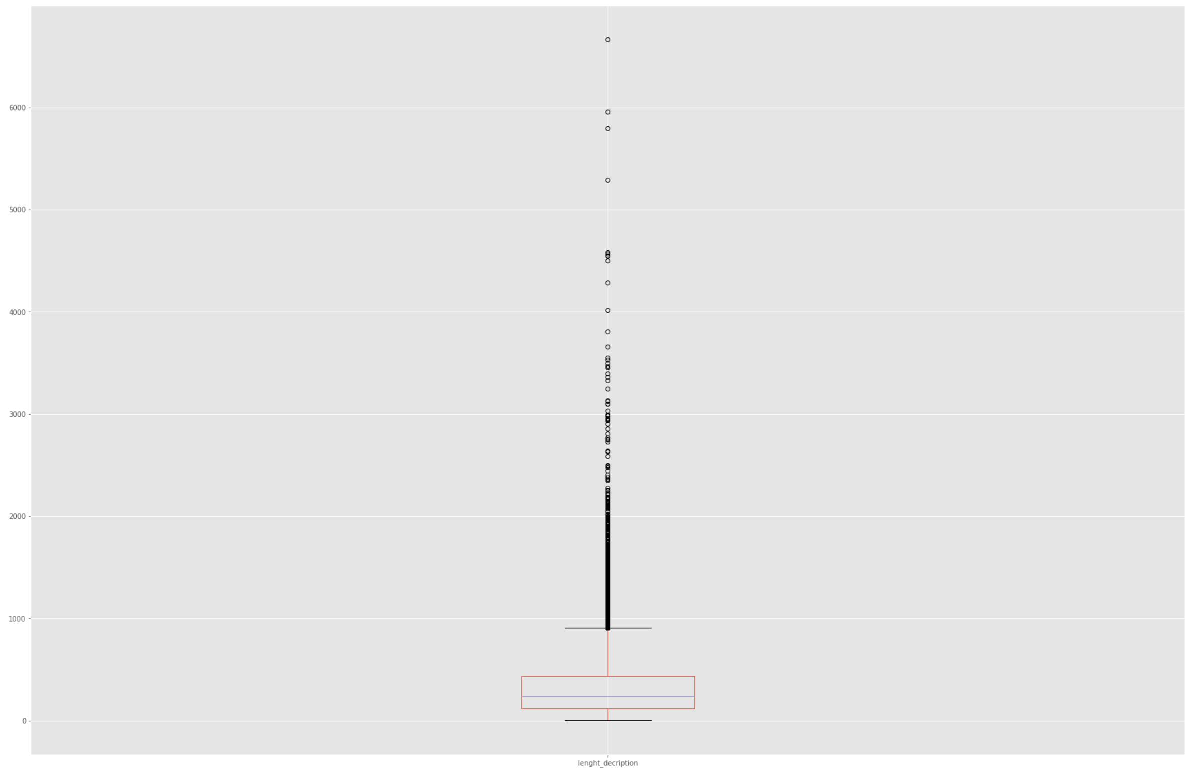
	Type	Name	Age	Breed1	Breed2	Gender	Color1	Color2	Color3	MaturitySize	...	full_c
0	cat	Nibble	3	299	0	1	1	7	0	1	...	BlackV
1	cat	no_name	1	265	0	1	1	2	0	2	...	BlackB
2	dog	Brisco	1	307	0	1	2	7	0	2	...	BrownV
3	dog	Miko	4	307	0	2	1	2	0	2	...	BlackB
4	dog	Hunter	1	307	0	1	1	0	0	2	...	E
...	...	...	...	...	...	...	...	...	...	...	...	
14988	cat	no_name	2	266	0	3	1	0	0	2	...	E
14989	cat	Serato & Eddie	24	265	264	3	1	4	7	2	...	BlackYellowV
14990	cat	Monkies	2	265	266	3	5	6	7	3	...	CreamGrayV

In [105]:

```
data["lenght_decription"] = data["Description"].apply(lambda x: len(x))
data["lenght_decription"].plot.box(figsize = (30, 20))
```

Out[105]:

<AxesSubplot:>



In [106]:

```
index,para = outlier_detect_IQR(data=data,col='lenght_decription',threshold=1)
print('Верхняя граница:',para[0],'\nНижняя граница:',para[1])
```

```
Количество выбросов в данных: 1334
Доля выбросов: 0.0914826498422713
Верхняя граница: 748.0
Нижняя граница: -197.0
```

In [107]:

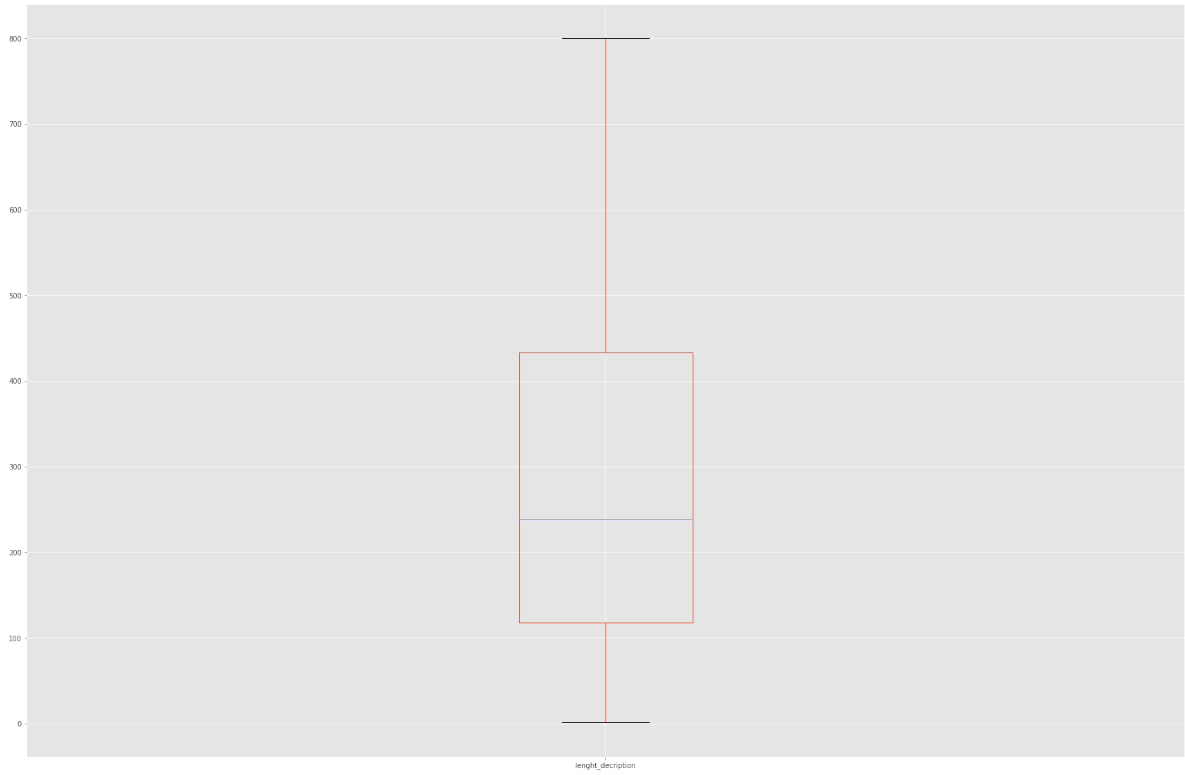
```
data = impute_outlier_with_arbitrary(data=data,outlier_index=index, value= 800, col=['lengh
```

In [108]:

```
data["lenght_decription"].plot.box(figsize = (30, 20))
```

Out[108]:

```
<AxesSubplot:>
```

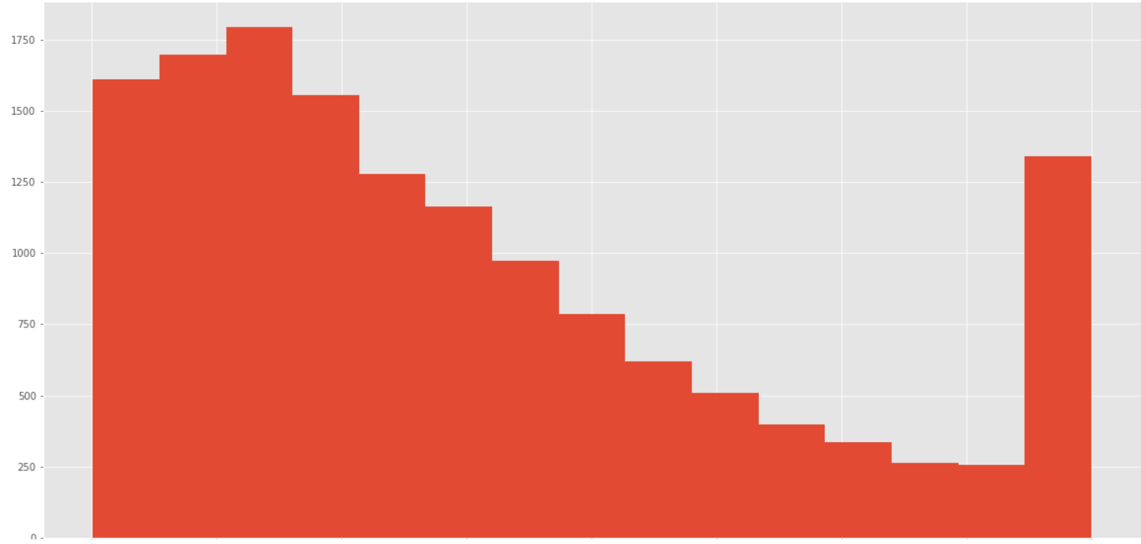


In [109]:

```
data["lenght_decription"].hist(figsize = (20, 10), bins = 15)
```

Out[109]:

<AxesSubplot:>

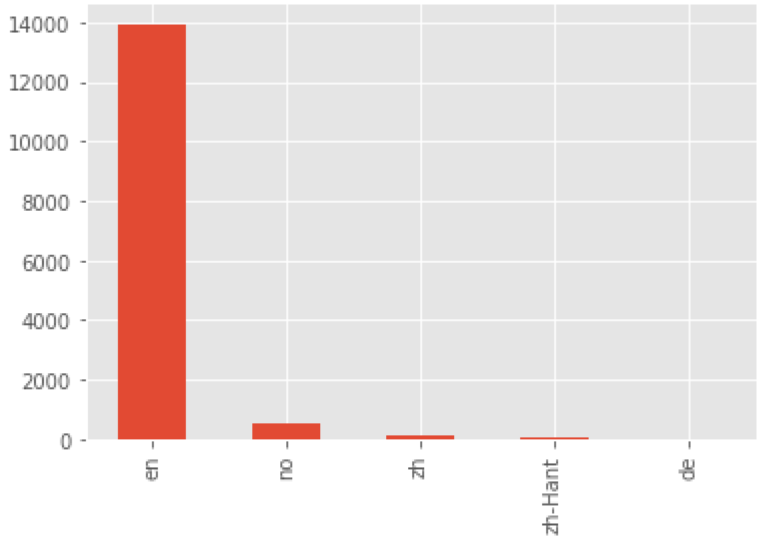


In [110]:

```
data["lang"].value_counts().plot.bar()
```

Out[110]:

<AxesSubplot:>



In [111]:

```
data["lang"].value_counts()
```

Out[111]:

```
en         13939
no           511
zh            94
zh-Hant       36
de             2
Name: lang, dtype: int64
```

In [112]:

```
data[data["lang"] == 'zh']["Description"][1002] # китайский (упрощенный)
```

Out[112]:

```
'小豹纹是一只两个月大的女生。她的性格非常活泼可爱。现在寻找一个有爱心，有耐心和有经
济能力的有缘人来领养她。请一定要带她打三支预防针，过后每年打一支以及每个月放猫虱药。
漂亮可爱的她在等着你带她回去哦！'
```

In [113]:

```
data[data["lang"] == 'en']["Description"][4] # английский
```

Out[113]:

```
"This handsome yet cute boy is up for adoption. He is the most playful pal w
e've seen in our puppies. He loves to nibble on shoelaces , Chase you at suc
h a young age. Imagine what a cute brat he will be when he grows. We are loo
king for a loving home for Hunter , one that will take care of him and give
him the love that he needs. Please call urgently if you would like to adopt
this cutie."
```

In [114]:

```
data[data["lang"] == 'zh-Hant']["Description"][571] # китайский (традиционный)
```

Out[114]:

```
'有人可以給孩子們一個家嗎？ 有養貓經驗者優先... Whatsapp 救起來時，滿身黑油，好可
憐，可以給孩子一個家嗎？ Puchong area........... 性格比较害怕人，只可以养在室内，
要有养猫经验，要有耐心和他接触。。......'
```

In [115]:

```
data[data["lang"] == 'de']["Description"][14314] # немецкий
```

Out[115]:

```
'Kiki Sgt manja dan aktiv.'
```

In [116]:

```
data.shape
```

Out[116]:

```
(14582, 42)
```

In [117]:

```
data["lang"] = data["lang"].apply(lambda x: np.nan if x == 'de' else x)
data.dropna(inplace=True)
data.shape
```

Out[117]:

```
(14580, 42)
```

In [118]:

```
data["lang"].value_counts()
```

Out[118]:

```
en         13939
no           511
zh            94
zh-Hant       36
Name: lang, dtype: int64
```

In [119]:

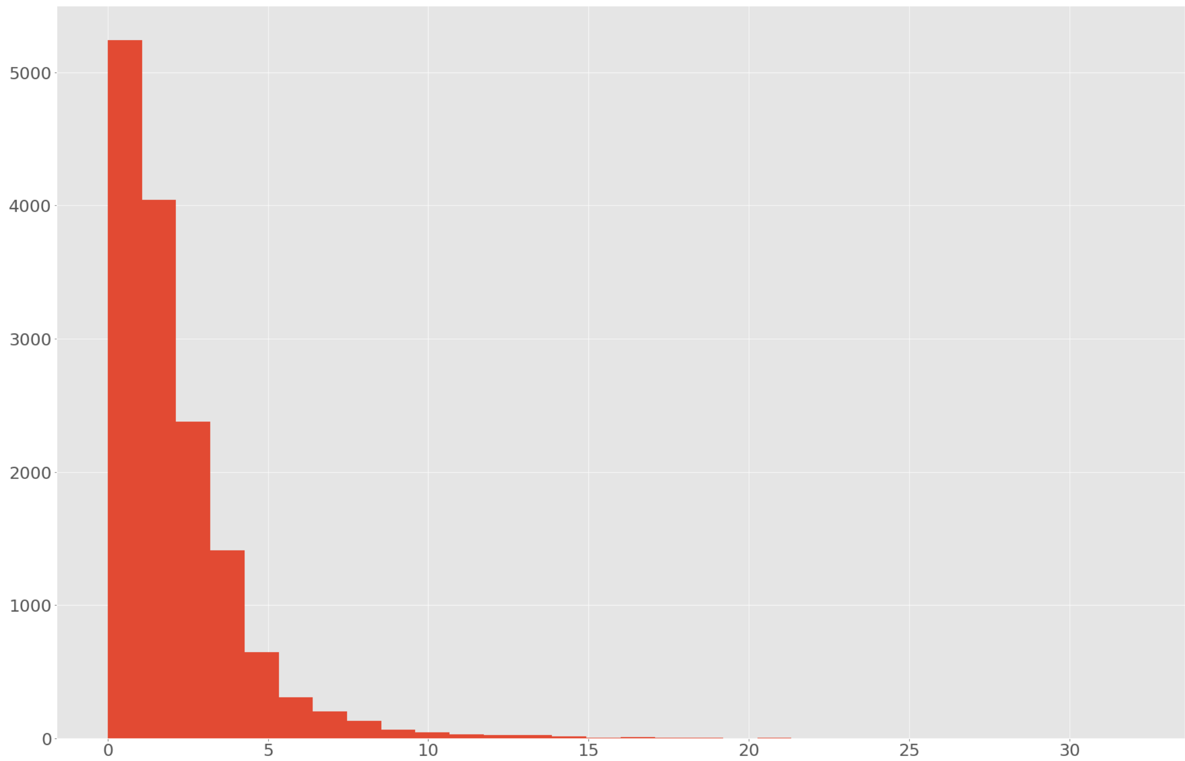
```
data["lang"] = data["lang"].apply(lambda x: 'zh' if x == 'zh-Hant' else x)
```

In [120]:

```
data["magnitude"].hist(bins = 30, figsize = (30, 20), xlabelsize=25, ylabelsize=25)
```

Out[120]:

```
<AxesSubplot:>
```

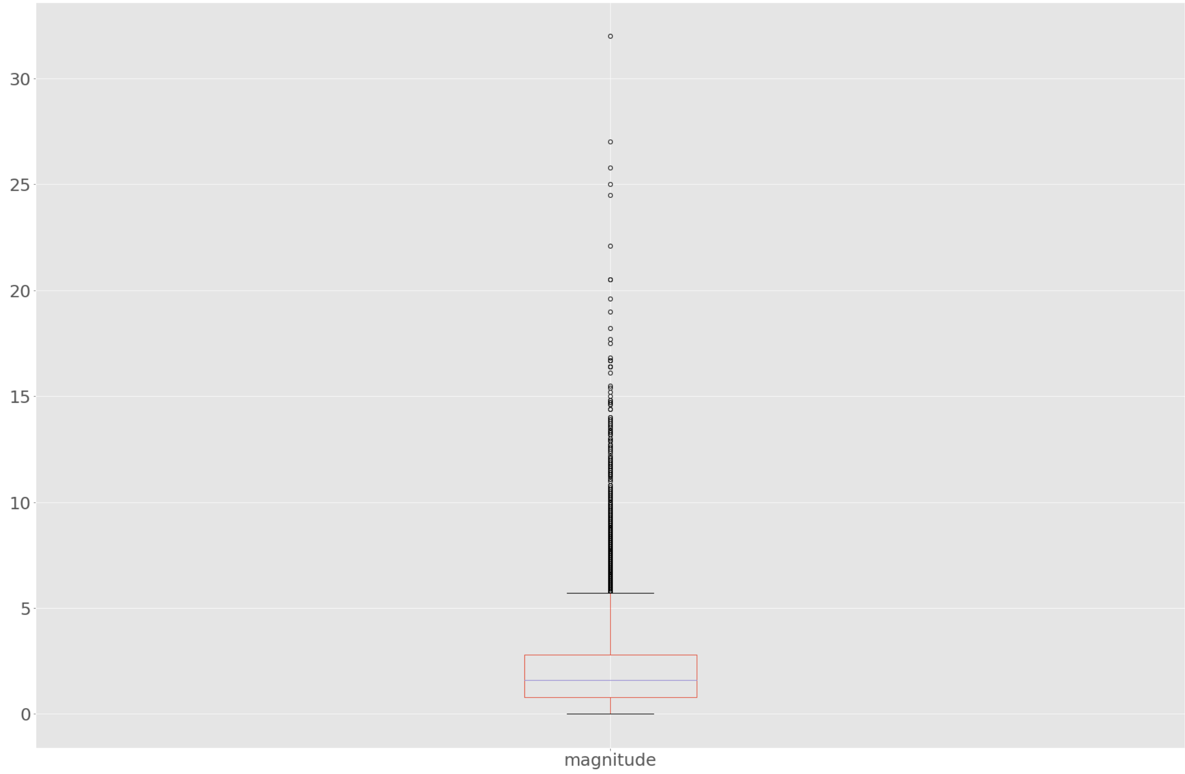


In [121]:

```
data["magnitude"].plot.box(fontsize=25, figsize=(30,20))
```

Out[121]:

```
<AxesSubplot:>
```



In [122]:

```
d_neg = data[data["score"] < -0.25][["Description", "score", "magnitude"]]
d_neg[d_neg["magnitude"] > 2]
```

Out[122]:

	Description	score	magnitude
540	Meet Baby Rosemary, one of the puppies that we...	-0.4	4.1
1544	Her name is Nicky She was dumped by her owner ...	-0.3	2.1
1981	please help me rescue this little baby..he's a...	-0.3	3.5
2603	I found these poor kittens in Taipan, Subang. ...	-0.3	4.0
4561	Sep SPCA Ampang is relocating to a smaller pla...	-0.3	2.9
7271	I found her & her brother wandering about near...	-0.3	2.5
7566	Latte is one of three kittens that were rescue...	-0.3	4.6
8046	suspected 2b lost, but posted everywhere tryin...	-0.3	3.0
8668	4 year old female siberian husky for adoption ...	-0.3	4.1
8915	I found him when he was about 4 months, at our...	-0.3	2.7
10583	A mother cat gave birth to six kittens near my...	-0.3	2.5
10631	I found these poor kittens in Taipan, Subang. ...	-0.3	4.0
10744	My friend rescued a toy poodle from drainage n...	-0.4	3.2
12431	Found this little baby running on the road whe...	-0.4	2.3
12958	Spotty is a beige color local female puppy. Va...	-0.5	3.0
14541	***11 days left!!! ***The time is running out ...	-0.3	6.3
14688	Her name is White She was dumped by her owner ...	-0.3	2.1
14827	Coffee, 9 months old Doberman mix. Male. 2 mon...	-0.3	2.9

In [123]:

```
index,para = outlier_detect_IQR(data=data,col='magnitude',threshold=1)
print('Верхняя граница:',para[0],'\nНижняя граница:',para[1])
```

```
Количество выбросов в данных: 1078
Доля выбросов: 0.07393689986282578
Верхняя граница: 4.8
Нижняя граница: -1.1999999999999997
```

In [124]:

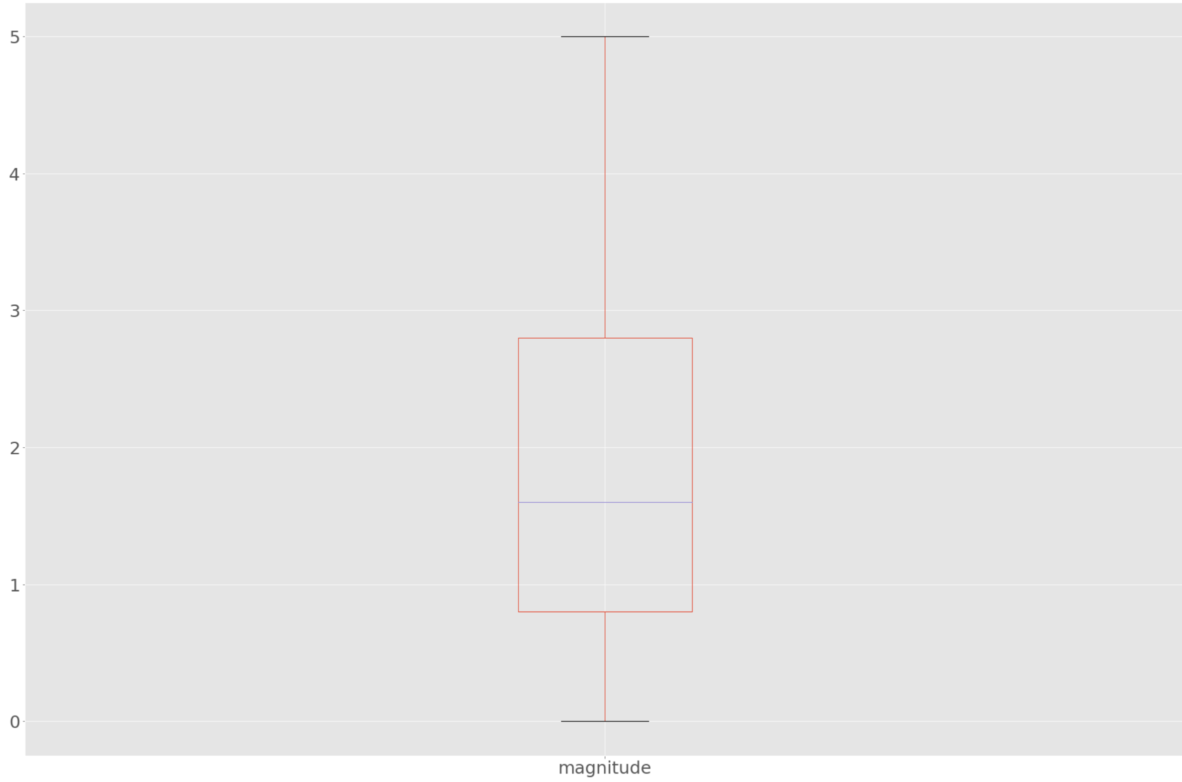
```
data = impute_outlier_with_arbitrary(data=data,outlier_index=index, value= 5, col=['magnitu
```

In [125]:

```
data["magnitude"].plot.box(fontsize=25, figsize=(30,20))
```

Out[125]:

```
<AxesSubplot:>
```

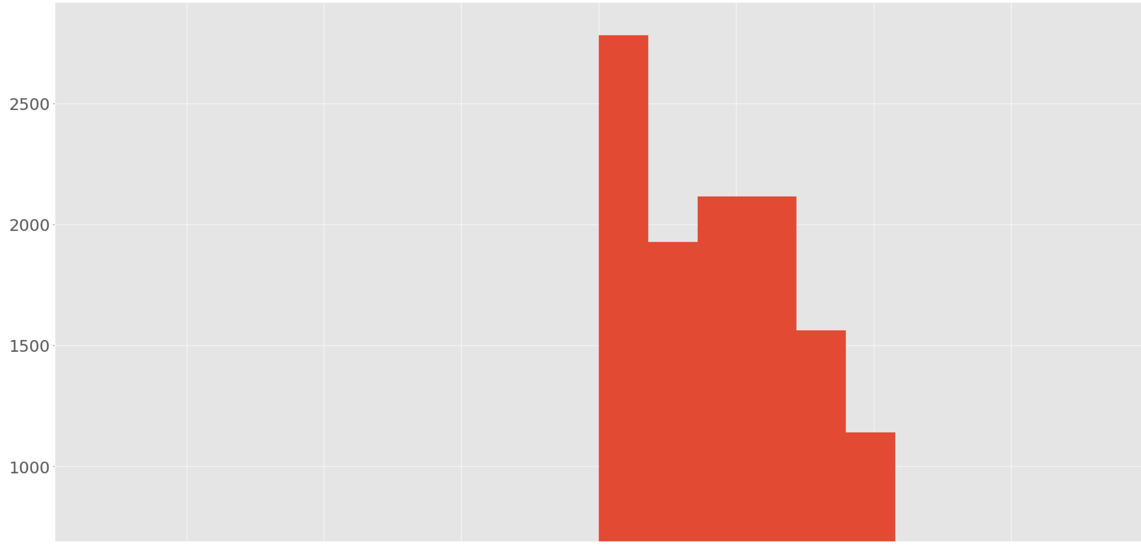


In [126]:

```
data["score"].hist(bins = 20, figsize = (30, 20), xlabelsize=25, ylabelsize=25)
```

Out[126]:

<AxesSubplot:>



Информация с Google Vision API

In [127]:

```
metadata_dict = {}
i = 0
for filename in os.listdir('../petfinder/train_metadata/'):
    with open('../petfinder/train_metadata/' + filename, 'r', errors='ignore') as f:
        metadata = json.load(f)
    pet_id = filename.split('.')[0]
    if pet_id[-1] == '1':
        metadata_dict[pet_id[:-2]] = {}
        if 'labelAnnotations' in metadata:
            index = 0
            for i in range(0, len(metadata['labelAnnotations'])):
                desc = metadata['labelAnnotations'][i]['description']
                if desc.find('dog') != -1 or desc.find('cat') != -1:
                    index = i
                    break
            metadata_dict[pet_id[:-2]]['object_in_img'] = metadata['labelAnnotations'][inde
            metadata_dict[pet_id[:-2]]['score_in_img'] = metadata['labelAnnotations'][index
        else:
            metadata_dict[pet_id[:-2]]['object_in_img'] = 'no'
            metadata_dict[pet_id[:-2]]['score_in_img'] = 0
metadata_dict
```

Out[127]:


```
{'0008c5398': {'object_in_img': 'cat', 'score_in_img': 0.9943703},
 '000a290e4': {'object_in_img': 'dog', 'score_in_img': 0.96414083},
 '000fb9572': {'object_in_img': 'dog', 'score_in_img': 0.97213346},
 '0011d7c25': {'object_in_img': 'cat', 'score_in_img': 0.9923178},
 '00156db4a': {'object_in_img': 'dog', 'score_in_img': 0.95605063},
 '001a1aaad': {'object_in_img': 'cat', 'score_in_img': 0.97333777},
 '001b1507c': {'object_in_img': 'cat', 'score_in_img': 0.99399006},
 '002230dea': {'object_in_img': 'cat', 'score_in_img': 0.6242952},
 '002278114': {'object_in_img': 'skin', 'score_in_img': 0.9343813},
 '002278114-': {'object_in_img': 'cat', 'score_in_img': 0.99444574},
 '0025a8313': {'object_in_img': 'cat', 'score_in_img': 0.97613597},
 '0038234c6': {'object_in_img': 'dog', 'score_in_img': 0.9712321},
 '0038c9343': {'object_in_img': 'dog', 'score_in_img': 0.9496203},
 '003dd2e26': {'object_in_img': 'cat', 'score_in_img': 0.91389936},
 '0045ed62a': {'object_in_img': 'cat', 'score_in_img': 0.99238837},
 '004709939': {'object_in_img': 'cat', 'score_in_img': 0.9907051},
 '004a26127': {'object_in_img': 'dog', 'score_in_img': 0.9645945},
 '004c2f355': {'object_in_img': 'cat', 'score_in_img': 0.9947366},
```

In [128]:

```
data['object_in_img'] = data['PetID'].apply(lambda x: metadata_dict[x]['object_in_img'] if
data['score_in_img'] = data['PetID'].apply(lambda x: metadata_dict[x]['score_in_img'] if x
data
```

Out[128]:

	Type	Name	Age	Breed1	Breed2	Gender	Color1	Color2	Color3	MaturitySize	...
0	cat	Nibble	3	299	0	1	1	7	0	1	...
1	cat	no_name	1	265	0	1	1	2	0	2	...
2	dog	Brisco	1	307	0	1	2	7	0	2	...
3	dog	Miko	4	307	0	2	1	2	0	2	...
4	dog	Hunter	1	307	0	1	1	0	0	2	...
...	...	...	...	...	...	...	...	...	...	...	...
14988	cat	no_name	2	266	0	3	1	0	0	2	...
14989	cat	Serato & Eddie	24	265	264	3	1	4	7	2	...
14990	cat	Monkies	2	265	266	3	5	6	7	3	...
14991	cat	Ms Daym	9	266	0	2	4	7	0	1	...
14992	dog	Fili	1	307	307	1	2	0	0	2	...

14580 rows × 44 columns

In [129]:

```
data["object_in_img"].value_counts()
```

Out[129]:

```
cat                 6273
dog                 5875
dog breed           1193
dog like mammal      646
no                   333
                    ...
clothing               1
hair                   1
hand                   1
meal                   1
road                   1
Name: object_in_img, Length: 64, dtype: int64
```

In [130]:

```
data["object_in_img"] = data["object_in_img"].apply(lambda x: "cat" if x.find("cat") != -1
```

In [131]:

```
data["object_in_img"].value_counts()
```

Out[131]:

```
dog                  7802
cat                  6323
no                    333
fauna                  23
mammal                 11
cage                    8
plant                   5
floor                   4
furniture               4
structure               4
yellow                  3
blue                    3
skin                    3
car                     3
text                    3
face                    3
textile                 2
grass                   2
black                   2
light                   2
animal shelter          2
product                 2
vertebrate              2
fur                     2
hand                    1
rock                    1
window                  1
plush                   1
leg                     1
fashion accessory       1
photo caption           1
wheel                   1
footwear                1
white                   1
iron                    1
facial hair             1
wildlife                1
room                    1
stairs                  1
collage                 1
road                    1
whiskers                1
property                1
pink                    1
people                  1
nature reserve          1
red                     1
hair                    1
stuffed toy             1
meal                    1
wood                    1
clothing                1
snout                   1
Name: object_in_img, dtype: int64
```

In [132]:

```
data["object_in_img"].value_counts().drop('dog').drop('cat').drop('no').sum()
```

Out[132]:

```
122
```

In [133]:

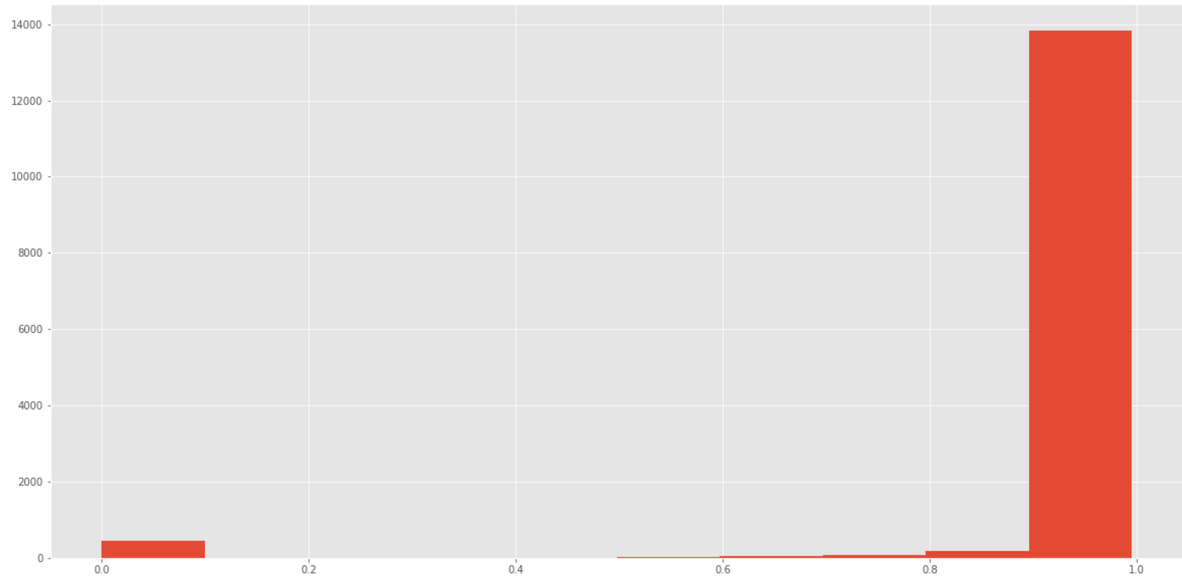
```
data["object_in_img"] = data["object_in_img"].apply(lambda x: "cat" if x.find("cat") != -1
data.loc[data["object_in_img"] == 'no', "score_in_img"] = 0
```

In [134]:

```
data["score_in_img"].hist(figsize=(20,10))
```

Out[134]:

```
<AxesSubplot:>
```

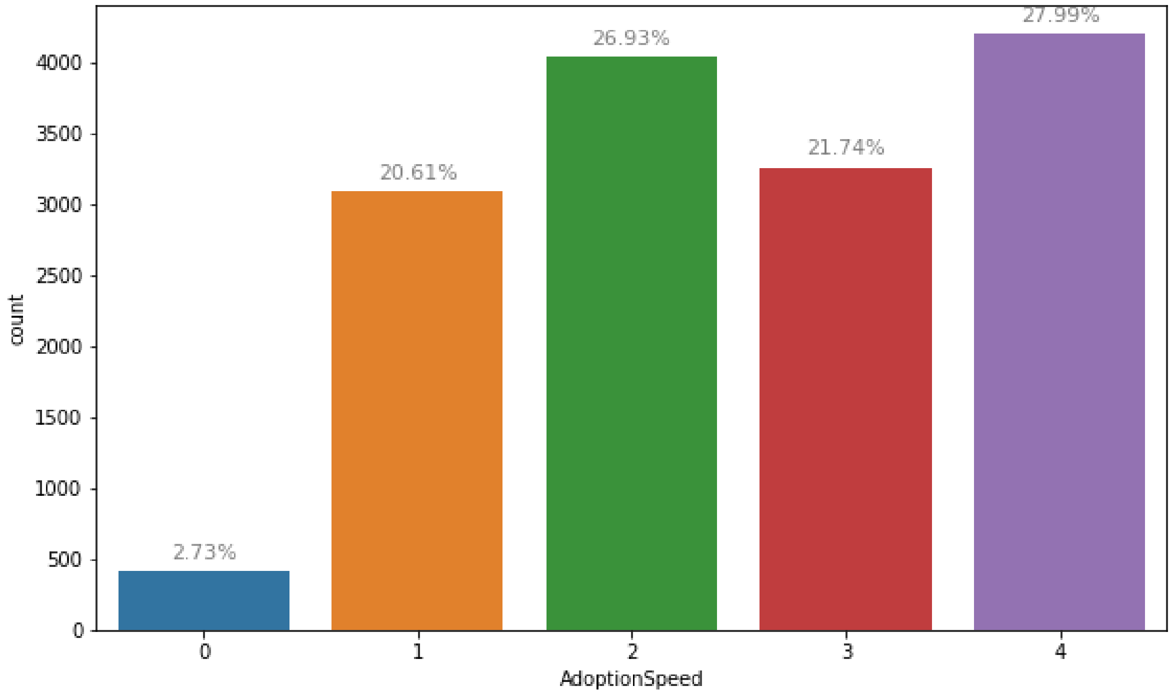


Целевая переменная (скорость, с которой заберут питомца)

- 0 — питомец был принят в семью в тот же день, как его занесли в список
- 1 — животное было принято в семью в период от 1 до 7 дней (1 неделя) после внесения в список
- 2 — животное было принято в семью в период от 8 до 30 дней (1 месяц) после внесения в список
- 3 — животное было принято в семью в период от 31 до 90 дней (2-3 месяц) после внесения в список
- 4 — животное не было принято в семью после 100 дней ожидания

In [10]:

```
plt.figure(figsize=(10, 6));
g = sns.countplot(x='AdoptionSpeed', data=data)
# plt.title('Количество животных в каждом из классов');
ax=g.axes
for p in ax.patches:
     ax.annotate(f"{p.get_height() * 100 / data.shape[0]:.2f}%", (p.get_x() + p.get_width()
         ha='center', va='center', fontsize=11, color='gray', rotation=0, xytext=(0, 10),
         textcoords='offset points')
```



In [11]:

```
data["AdoptionSpeed"].value_counts()
```

Out[11]:

```
4    4197
2    4037
3    3259
1    3090
0     410
Name: AdoptionSpeed, dtype: int64
```

Выбираем признаки для обучения

Препроцессинг

In [136]:

```
data.columns
```

Out[136]:

```
Index(['Type', 'Name', 'Age', 'Breed1', 'Breed2', 'Gender', 'Color1', 'Color
2',
       'Color3', 'MaturitySize', 'FurLength', 'Vaccinated', 'Dewormed',
       'Sterilized', 'Health', 'Quantity', 'Fee', 'State', 'RescuerID',
       'VideoAmt', 'Description', 'PetID', 'PhotoAmt', 'AdoptionSpeed',
       'No_name', 'Pure_breed', 'Breed1_name', 'Breed2_name', 'Color1_name',
       'Color2_name', 'Color3_name', 'full_color', 'full_health', 'one_pet',
       'Free', 'State_name', 'RankRescuer', 'has_video', 'lang', 'magnitud
e',
       'score', 'lenght_decription', 'object_in_img', 'score_in_img'],
      dtype='object')
```

In [137]:

```
data_tree = data.copy()
```

In [138]:

```
data_tree["Gender"] = data_tree["Gender"].apply(lambda x: 'male' if x == 1 else ('female' i
data_tree["MaturitySize"] = data_tree["MaturitySize"].apply(lambda x: 'small' if x == 1 els
data_tree["FurLength"] = data_tree["FurLength"].apply(lambda x: 'short' if x == 1 else ('me
data_tree["Vaccinated"] = data_tree["Vaccinated"].apply(lambda x: 'yes' if x == 1 else ('no
data_tree["Dewormed"] = data_tree["Dewormed"].apply(lambda x: 'yes' if x == 1 else ('no' if
data_tree["Sterilized"] = data_tree["Sterilized"].apply(lambda x: 'yes' if x == 1 else ('no
data_tree["Health"] = data_tree["Health"].apply(lambda x: 'Healthy' if x == 1 else ('Minor
```

In [139]:

```
data_tree = data_tree[['Type', 'No_name', 'Age','Breed1', 'Breed2', 'Gender', 'Color1_name'
                       'MaturitySize', 'FurLength', 'Vaccinated', 'Dewormed', 'Sterilized',
                       'Quantity', 'Fee', 'State_name', 'RankRescuer', 'has_video', 'PhotoA
                       'score', 'lenght_decription', 'object_in_img', 'score_in_img', 'Adop
```

In [140]:

```
def encodeTextVariable(data, variables):
    for var in variables:
        labelEncoder = LabelEncoder()
        data[var] = labelEncoder.fit_transform(data[var])

encodeTextVariable(data=data_tree, variables=['Type', 'Breed1', 'Breed2', 'Gender', 'Maturi
                                              'Vaccinated', 'Dewormed', 'Sterilized', 'Heal
                                              'Color1_name', 'Color2_name', 'Color3_name',
                                              'lang', 'object_in_img'])
data_tree
```

Out[140]:

	Type	No_name	Age	Breed1	Breed2	Gender	Color1_name	Color2_name	Color3_nan
0	0	0	3	164	0	1	0	5	
1	0	1	1	133	0	1	0	1	
2	1	0	1	172	0	1	1	5	
3	1	0	4	172	0	0	0	1	
4	1	0	1	172	0	1	0	0	
...	...	...	...	...	...	...	...	...	
14988	0	1	2	134	0	2	0	0	
14989	0	0	24	133	99	2	0	6	
14990	0	0	2	133	101	2	2	4	
14991	0	0	9	134	0	0	6	5	
14992	1	0	1	172	132	1	1	0	

14580 rows × 28 columns

In [141]:

```
X = data_tree.drop('AdoptionSpeed', axis=1)
y = data_tree['AdoptionSpeed']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42, s
X_train.shape, X_test.shape, y_train.shape, y_test.shape
```

Out[141]:

```
((11664, 27), (2916, 27), (11664,), (2916,))
```

Target Encoding + Normalization

In [142]:

```
to_encode = ['Gender', 'MaturitySize', 'FurLength', 'Vaccinated', 'Dewormed',
                      'Sterilized', 'Health', 'Color1_name', 'Color2_name', 'Color3_name',
                      'State_name', 'lang', 'object_in_img']
target_enc = ce.TargetEncoder(cols=to_encode).fit(X_train,y_train)
X_train_tar = target_enc.transform(X_train)
X_test_tar = target_enc.transform(X_test)
```

In [143]:

```
ss = StandardScaler().fit(X_train_tar)
X_train_tar = ss.transform(X_train_tar)
X_test_tar = ss.transform(X_test_tar)
y_train_tar = y_train
y_test_tar = y_test
```

One-Hot Encoding + Normalizaton

In [144]:

```
to_dummies = [ # переменные, которые сейчас не числовые
    'Gender', 'MaturitySize', 'FurLength', 'Vaccinated', 'Dewormed',
                      'Sterilized', 'Health', 'Color1_name', 'Color2_name', 'Color3_name',
                      'State_name', 'lang', 'object_in_img']

# Закодированные категориальные переменные методом OneHot Encoding
data_ohe = pd.get_dummies(data_tree, columns=to_dummies, drop_first=True)
data_ohe.shape
```

Out[144]:

```
(14580, 56)
```

In [145]:

```
X_ohe = data_ohe.drop('AdoptionSpeed', axis=1)
y_ohe = data_ohe['AdoptionSpeed']
X_train_ohe, X_test_ohe, y_train_ohe, y_test_ohe = train_test_split(X_ohe, y_ohe, test_size
X_train_ohe.shape, X_test_ohe.shape, y_train_ohe.shape, y_test_ohe.shape
```

Out[145]:

```
((11664, 55), (2916, 55), (11664,), (2916,))
```

In [146]:

```
ss = StandardScaler().fit(X_train_ohe)
X_train_ohe = ss.transform(X_train_ohe)
X_test_ohe = ss.transform(X_test_ohe)
```

Построим baseline

Необходимо построить baseline. Хороший baseline копирует распределение целевой переменной на train.

In [147]:

```
y_train.value_counts(normalize=True) # смотрим изначальное распределение целевой переменной
```

Out[147]:

```
4    0.276063
2    0.271433
3    0.219050
1    0.206361
0    0.027092
Name: AdoptionSpeed, dtype: float64
```

In [152]:

```
y_naive_pred = np.random.choice(
    [4., 2., 3., 1., 0.],
    len(y_test),
    p=y_train.value_counts(normalize=True).values) # p - вероятности
```

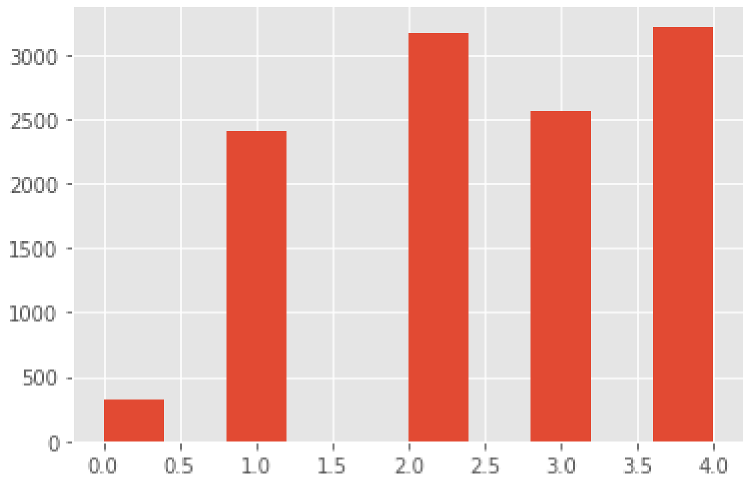
Наивное предсказание в точности повторяет распределение тренировочной выборки

In [153]:

```
y_train.hist()
```

Out[153]:

```
<AxesSubplot:>
```

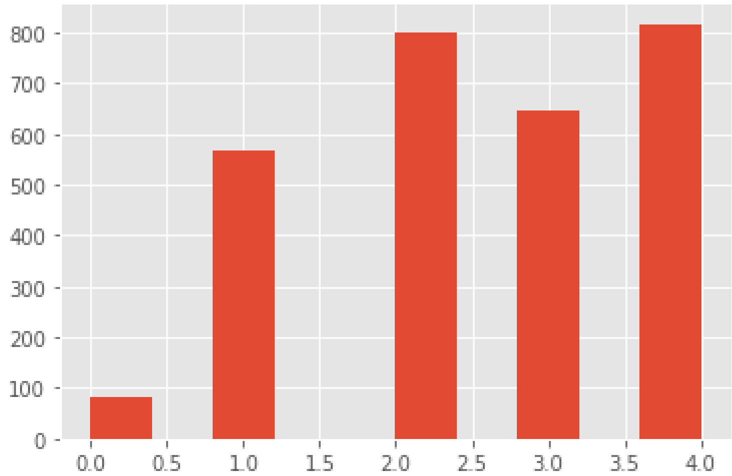


In [154]:

```
plt.hist(y_naive_pred)
```

Out[154]:

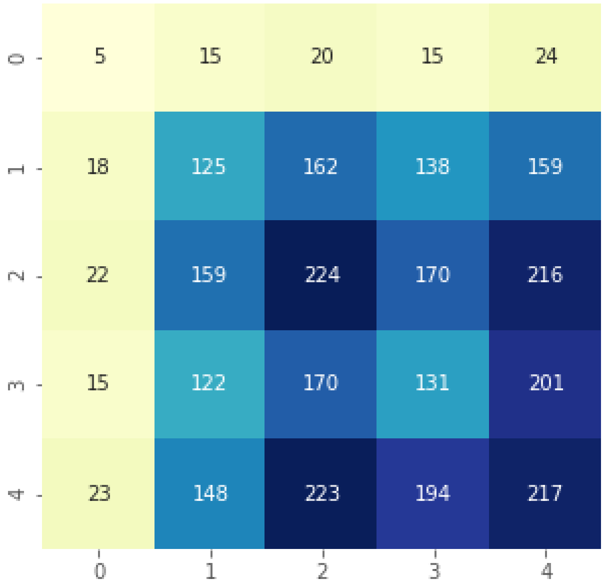
```
(array([ 83.,   0., 569.,   0.,   0., 799.,   0., 648.,   0., 817.]),
 array([0. , 0.4, 0.8, 1.2, 1.6, 2. , 2.4, 2.8, 3.2, 3.6, 4. ]),
 <BarContainer object of 10 artists>)
```



In [155]:

```
print(cohen_kappa_score(y_test, y_naive_pred, weights='quadratic'))

cm = confusion_matrix(y_test, y_naive_pred)

conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
# внизу предсказанные метки, слева - истинные метки
```

```
0.021974708694860734
```



Деревья решений

In [156]:

```
tree_clf = DecisionTreeClassifier(max_depth=2, class_weight='balanced') # кол-во разбиений
tree_clf.fit(X_train, y_train)
```

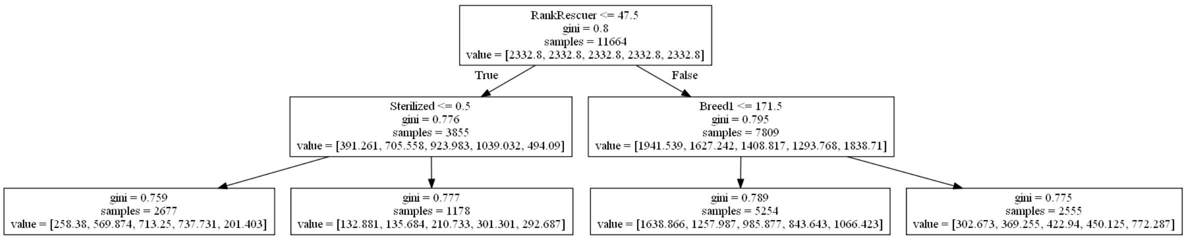
Out[156]:

```
DecisionTreeClassifier(class_weight='balanced', max_depth=2)
```

In [157]:

```
graph = Source(sklearn.tree.export_graphviz(tree_clf, out_file=None, feature_names=X.column
png_bytes = graph.pipe(format='png')
with open('dtree_pipe.png','wb') as f:
    f.write(png_bytes)

from IPython.display import Image
Image(png_bytes)
```

Out[157]:



In [158]:

```
print(cohen_kappa_score(y_test, tree_clf.predict(X_test), weights='quadratic'))
```

```
0.09047269931245372
```

In [159]:

```
tree_clf = DecisionTreeClassifier(max_depth=2, class_weight='balanced') # кол-во разбиений
tree_clf.fit(X_train_ohe, y_train_ohe)
```

Out[159]:

```
DecisionTreeClassifier(class_weight='balanced', max_depth=2)
```

In [160]:

```
print(cohen_kappa_score(y_test_ohe, tree_clf.predict(X_test_ohe), weights='quadratic'))
```

```
0.09047269931245372
```

In [161]:

```
tree_clf = DecisionTreeClassifier(max_depth=2, class_weight='balanced') # кол-во разбиений
tree_clf.fit(X_train_tar, y_train_tar)
```

Out[161]:

```
DecisionTreeClassifier(class_weight='balanced', max_depth=2)
```

In [162]:

```
print(cohen_kappa_score(y_test_tar, tree_clf.predict(X_test_tar), weights='quadratic'))
```

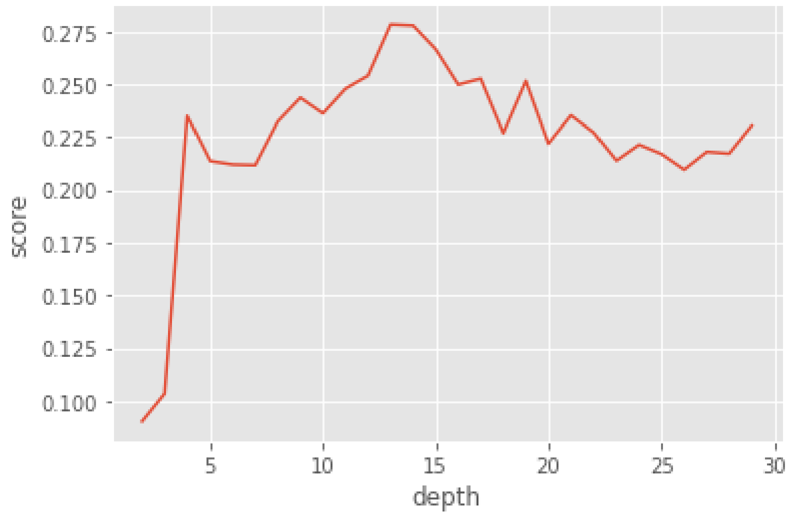
```
0.09047269931245372
```

In [163]:

```
scores =[]
for depth in range(2, 30):
    tree_clf = DecisionTreeClassifier(max_depth=depth, class_weight='balanced')
    tree_clf.fit(X_train, y_train)
    scores.append(cohen_kappa_score(y_test, tree_clf.predict(X_test), weights='quadratic'))
```

In [164]:

```
plt.plot(range(2, 30), scores)
plt.xlabel('depth')
plt.ylabel('score')
plt.show()
```



In [165]:

```
# функция для подбора наилучших параметров
def grid_search_cv(model, param_grid, x_train, y_train):
    kfold = StratifiedKFold(n_splits=10, shuffle=True, random_state=7)
    kappa_scorer = make_scorer(cohen_kappa_score, weights = 'quadratic')
    grid_search = GridSearchCV(model, param_grid, cv=kfold, scoring=kappa_scorer, verbose=4
    t_start = time.time()
    grid_search.fit(x_train, y_train)
    t_end = time.time()
    print('model {} best score is {}'.format(model.__class__.__name__, grid_search.best_sco
    print('time for training is {} seconds'.format(t_end - t_start))
    print(f"Best params = {grid_search.best_estimator_}")
    return grid_search.best_estimator_
```

In [166]:

```
# функция для подбора наилучших параметров
def randomized_cv(model, param_grid, x_train, y_train, n_iter = 20):
    kfold = StratifiedKFold(n_splits=10, shuffle=True, random_state=7)
    kappa_scorer = make_scorer(cohen_kappa_score, weights = 'quadratic')
    grid_search = RandomizedSearchCV(model, param_grid, cv=kfold, scoring=kappa_scorer, ver
    t_start = time.time()
    grid_search.fit(x_train, y_train)
    t_end = time.time()
    print('model {} best accuracy score is {}'.format(model.__class__.__name__, grid_search
    print('time for training is {} seconds'.format(t_end - t_start))
    print(grid_search.best_score_)
    print(f"Best params = {grid_search.best_estimator_}")
    return grid_search.best_estimator_
```

In [167]:

```
param_grid = {
    'max_depth': range(2,30),
    'min_samples_leaf': list(range(3,11)), # минимальное количество наблюдений в листе
    'class_weight': [None, 'balanced'],
    'criterion': ["gini", "entropy"]
}
tree_model = grid_search_cv(DecisionTreeClassifier(random_state=42), param_grid, X_train, y
```

```
Fitting 10 folds for each of 896 candidates, totalling 8960 fits
[CV 1/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 2/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 3/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 4/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 5/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 6/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 7/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 8/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 9/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
```

In [168]:

```
tree_model = grid_search_cv(DecisionTreeClassifier(random_state=42), param_grid, X_train_oh
```

```
Fitting 10 folds for each of 896 candidates, totalling 8960 fits
[CV 1/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 2/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 3/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 4/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 5/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 6/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 7/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 8/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 9/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
```

In [169]:

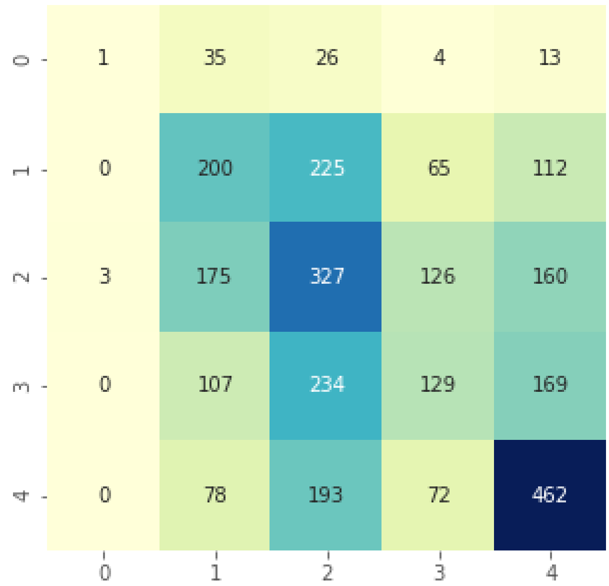
```
tree_model = grid_search_cv(DecisionTreeClassifier(random_state=42), param_grid, X_train_ta
```

```
Fitting 10 folds for each of 896 candidates, totalling 8960 fits
[CV 1/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 2/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 3/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 4/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 5/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 6/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 7/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 8/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
[CV 9/10] END class_weight=None, criterion=gini, max_depth=2, min_samples_
leaf=3; total time=   0.0s
```

In [195]:

```
t_start = time.time()
tree_clf = DecisionTreeClassifier(max_depth=8, min_samples_leaf=3, random_state=42) # кол-в
tree_clf.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, tree_clf.predict(X_test), weights='quadratic')}
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, tree_clf.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

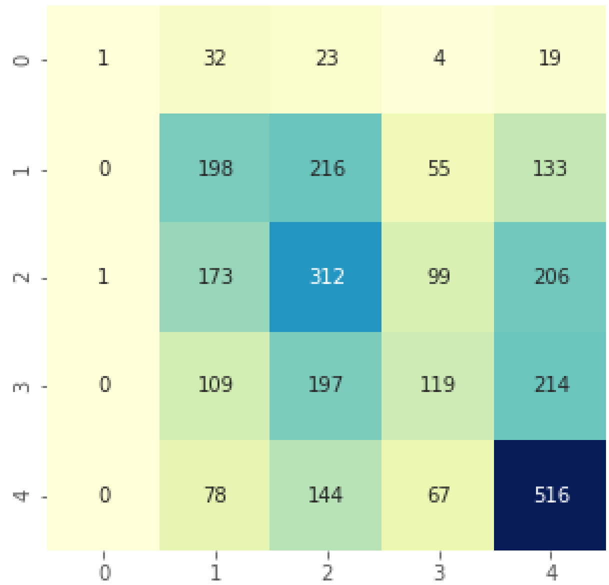
```
 Score = 0.3315742536320757
Time = 0.09474682807922363 seconds
```



In [196]:

```
t_start = time.time()
tree_clf = DecisionTreeClassifier(max_depth=8, min_samples_leaf=3, random_state=42)
tree_clf.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, tree_clf.predict(X_test_ohe), weights='quad
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, tree_clf.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.33502379545052933
Time = 0.14860272407531738 seconds
```



In [197]:

```
t_start = time.time()
tree_clf = DecisionTreeClassifier(max_depth=8, min_samples_leaf=3, random_state=42)
tree_clf.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, tree_clf.predict(X_test_tar), weights='quad
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, tree_clf.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.3218469396835203
Time = 0.09873580932617188 seconds
```

In [194]:

```
import warnings
warnings.filterwarnings("ignore")
```

Логистическая регрессия

In [198]:

```
log_reg = LogisticRegression()

log_reg.fit(X_train, y_train)

print(cohen_kappa_score(y_test, log_reg.predict(X_test), weights='quadratic'))
```

```
0.16762819323035805
```

In [199]:

```
log_reg = LogisticRegression()

log_reg.fit(X_train_ohe, y_train_ohe)

print(cohen_kappa_score(y_test_ohe, log_reg.predict(X_test_ohe), weights='quadratic'))
```

```
0.3127792475934328
```

In [200]:

```
log_reg = LogisticRegression()

log_reg.fit(X_train_tar, y_train_tar)

print(cohen_kappa_score(y_test_tar, log_reg.predict(X_test_tar), weights='quadratic'))
```

```
0.3183727797097937
```

In [201]:

```
param_grid = {
    'C': [0.1, 0.3, 0.5, 1.0],
    'class_weight': [None, 'balanced'],
    'solver': ['newton-cg', 'lbfgs', 'liblinear', 'sag']
}

log_reg_model = grid_search_cv(LogisticRegression(), param_grid, X_train, y_train)
```

```
Fitting 10 folds for each of 32 candidates, totalling 320 fits
[CV 1/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
25.6s
[CV 2/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
26.3s
[CV 3/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
20.3s
[CV 4/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
22.5s
[CV 5/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
23.0s
[CV 6/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
15.6s
[CV 7/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
22.0s
[CV 8/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
19.8s
[CV 9/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
25.1s
```

In [202]:

```
param_grid = {
    'C': [0.1, 0.3, 0.5, 1.0],
    'class_weight': [None, 'balanced'],
    'solver': ['newton-cg', 'lbfgs', 'liblinear', 'sag']
}

log_reg_model = grid_search_cv(LogisticRegression(), param_grid, X_train_ohe, y_train_ohe)
```

```
Fitting 10 folds for each of 32 candidates, totalling 320 fits
[CV 1/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.1s
[CV 2/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.2s
[CV 3/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.2s
[CV 4/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.2s
[CV 5/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.2s
[CV 6/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.1s
[CV 7/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.2s
[CV 8/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.3s
[CV 9/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
1.3s
[CV 10/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
```

In [203]:

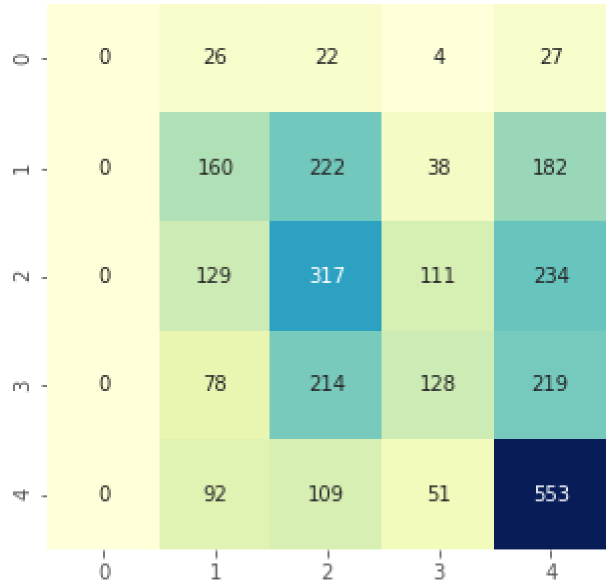
```
param_grid = {
    'C': [0.1, 0.3, 0.5, 1.0],
    'class_weight': [None, 'balanced'],
    'solver': ['newton-cg', 'lbfgs', 'liblinear', 'sag']
}

log_reg_model = grid_search_cv(LogisticRegression(), param_grid, X_train_tar, y_train_tar)
```

```
Fitting 10 folds for each of 32 candidates, totalling 320 fits
[CV 1/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 2/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 3/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 4/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 5/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 6/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 7/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.7s
[CV 8/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 9/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
0.8s
[CV 10/10] END ....C=0.1, class_weight=None, solver=newton-cg; total time=
```

In [204]:

```
t_start = time.time()
log_reg = LogisticRegression(C=0.3, solver='liblinear')
log_reg.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, log_reg.predict(X_test), weights='quadratic')}"
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, log_reg.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

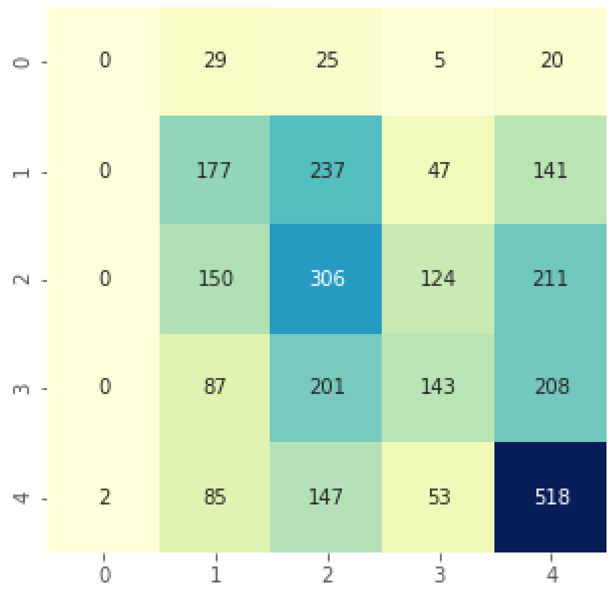
```
 Score = 0.282778124148O4937
Time = 2.5267982482910156 seconds
```



In [205]:

```
t_start = time.time()
log_reg = LogisticRegression(C=0.3)
log_reg.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, log_reg.predict(X_test_ohe), weights='quadr
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, log_reg.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

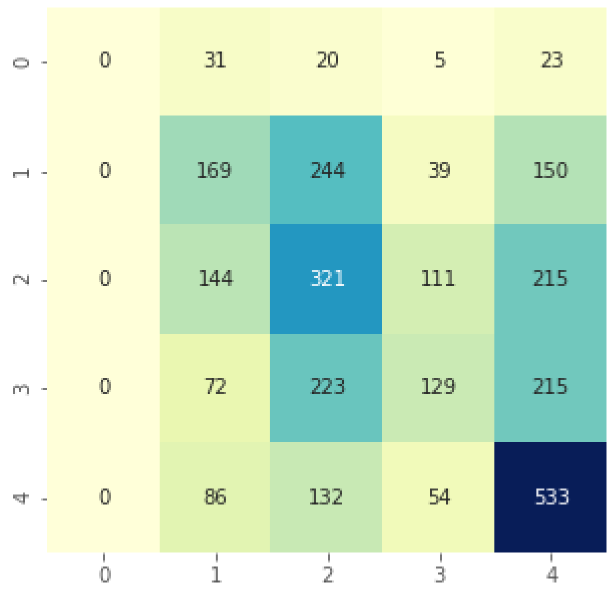
```
 Score = 0.3121781593532168
Time = 0.978381872177124 seconds
```



In [206]:

```
t_start = time.time()
log_reg = LogisticRegression(C=0.1)
log_reg.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, log_reg.predict(X_test_tar), weights='quadr
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, log_reg.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.316823522177170 25
Time = 0.48667168617248535 seconds
```



Ансамбли

Модель случайного леса

In [176]:

```
t_start = time.time()
r_forest = RandomForestClassifier()
r_forest.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, r_forest.predict(X_test), weights='quadratic')}
print(f"Time = {t_end - t_start} seconds")
```

```
 Score = 0.42468184626683303
Time = 3.275077342987060 5 seconds
```

In [177]:

```
t_start = time.time()
r_forest = RandomForestClassifier()
r_forest.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, r_forest.predict(X_test_ohe), weights='quad
print(f"Time = {t_end - t_start} seconds")
```

```
 Score = 0.41310541944009205
Time = 3.155869960784912 seconds
```

In [178]:

```
t_start = time.time()
r_forest = RandomForestClassifier()
r_forest.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, r_forest.predict(X_test_tar), weights='quad
print(f"Time = {t_end - t_start} seconds")
```

```
 Score = 0.4196636690065916
Time = 2.7579550743103027 seconds
```

In [179]:

```
param_grid = {
    'n_estimators': [100, 200, 300],
    'max_depth': range(2,20),
    'min_samples_leaf': [3, 5, 7, 9, 11], # минимальное количество наблюдений в листе
    'class_weight': [None, 'balanced'],
    'criterion': ["gini", "entropy"]
}
forest_model = randomized_cv(RandomForestClassifier(random_state=42), param_grid, X_train,
```

```
Fitting 10 folds for each of 40 candidates, totalling 400 fits
[CV 1/10; 1/40] START class_weight=None, criterion=gini, max_depth=17, min
_samples_leaf=7, n_estimators=200
[CV 1/10; 1/40] END class_weight=None, criterion=gini, max_depth=17, min_s
amples_leaf=7, n_estimators=200; total time=   3.5s
[CV 2/10; 1/40] START class_weight=None, criterion=gini, max_depth=17, min
_samples_leaf=7, n_estimators=200
[CV 2/10; 1/40] END class_weight=None, criterion=gini, max_depth=17, min_s
amples_leaf=7, n_estimators=200; total time=   3.3s
[CV 3/10; 1/40] START class_weight=None, criterion=gini, max_depth=17, min
_samples_leaf=7, n_estimators=200
[CV 3/10; 1/40] END class_weight=None, criterion=gini, max_depth=17, min_s
amples_leaf=7, n_estimators=200; total time=   3.3s
[CV 4/10; 1/40] START class_weight=None, criterion=gini, max_depth=17, min
_samples_leaf=7, n_estimators=200
[CV 4/10; 1/40] END class_weight=None, criterion=gini, max_depth=17, min_s
amples_leaf=7, n_estimators=200; total time=   3.3s
[CV 5/10; 1/40] START class_weight=None, criterion=gini, max_depth=17, min
_samples_leaf=7, n_estimators=200
```

In [180]:

```
forest_model = randomized_cv(RandomForestClassifier(random_state=42), param_grid, X_train_o
```

```
Fitting 10 folds for each of 40 candidates, totalling 400 fits
[CV 1/10; 1/40] START class_weight=balanced, criterion=gini, max_depth=10,
min_samples_leaf=5, n_estimators=200
[CV 1/10; 1/40] END class_weight=balanced, criterion=gini, max_depth=10, m
in_samples_leaf=5, n_estimators=200; total time=   2.7s
[CV 2/10; 1/40] START class_weight=balanced, criterion=gini, max_depth=10,
min_samples_leaf=5, n_estimators=200
[CV 2/10; 1/40] END class_weight=balanced, criterion=gini, max_depth=10, m
in_samples_leaf=5, n_estimators=200; total time=   2.6s
[CV 3/10; 1/40] START class_weight=balanced, criterion=gini, max_depth=10,
min_samples_leaf=5, n_estimators=200
[CV 3/10; 1/40] END class_weight=balanced, criterion=gini, max_depth=10, m
in_samples_leaf=5, n_estimators=200; total time=   2.7s
[CV 4/10; 1/40] START class_weight=balanced, criterion=gini, max_depth=10,
min_samples_leaf=5, n_estimators=200
[CV 4/10; 1/40] END class_weight=balanced, criterion=gini, max_depth=10, m
in_samples_leaf=5, n_estimators=200; total time=   2.6s
[CV 5/10; 1/40] START class_weight=balanced, criterion=gini, max_depth=10,
min_samples_leaf=5, n_estimators=200
```

In [181]:

```
forest_model = randomized_cv(RandomForestClassifier(random_state=42), param_grid, X_train_t
```

```
Fitting 10 folds for each of 40 candidates, totalling 400 fits
[CV 1/10; 1/40] START class_weight=balanced, criterion=entropy, max_depth=
8, min_samples_leaf=7, n_estimators=300
[CV 1/10; 1/40] END class_weight=balanced, criterion=entropy, max_depth=8,
min_samples_leaf=7, n_estimators=300; total time=   4.8s
[CV 2/10; 1/40] START class_weight=balanced, criterion=entropy, max_depth=
8, min_samples_leaf=7, n_estimators=300
[CV 2/10; 1/40] END class_weight=balanced, criterion=entropy, max_depth=8,
min_samples_leaf=7, n_estimators=300; total time=   4.8s
[CV 3/10; 1/40] START class_weight=balanced, criterion=entropy, max_depth=
8, min_samples_leaf=7, n_estimators=300
[CV 3/10; 1/40] END class_weight=balanced, criterion=entropy, max_depth=8,
min_samples_leaf=7, n_estimators=300; total time=   4.7s
[CV 4/10; 1/40] START class_weight=balanced, criterion=entropy, max_depth=
8, min_samples_leaf=7, n_estimators=300
[CV 4/10; 1/40] END class_weight=balanced, criterion=entropy, max_depth=8,
min_samples_leaf=7, n_estimators=300; total time=   4.7s
[CV 5/10; 1/40] START class_weight=balanced, criterion=entropy, max_depth=
8, min_samples_leaf=7, n_estimators=300
```

In [207]:

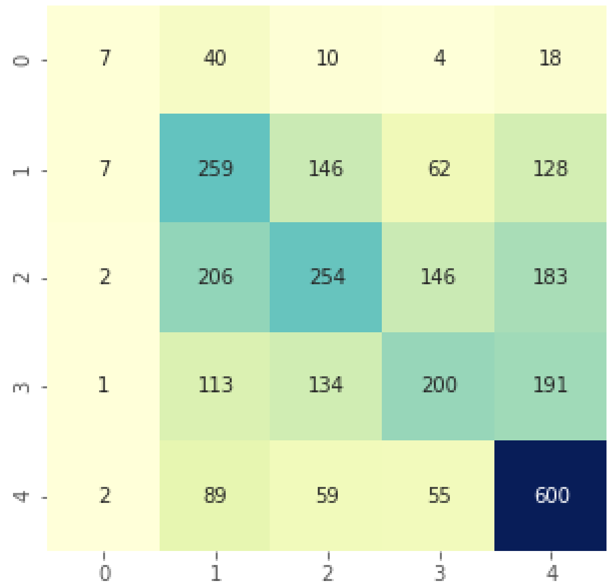
```
t_start = time.time()
r_forest = RandomForestClassifier(criterion='entropy', max_depth=16, min_samples_leaf=3,
                       n_estimators=300, random_state=42)
r_forest.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, r_forest.predict(X_test), weights='quadratic')}
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, r_forest.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.4098590420354743
Time = 13.883994102478027 seconds
```

In [208]:

```
t_start = time.time()
r_forest = RandomForestClassifier(class_weight='balanced', max_depth=19,
                       min_samples_leaf=3, n_estimators=300, random_state=42)
r_forest.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, r_forest.predict(X_test_ohe), weights='quad
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, r_forest.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

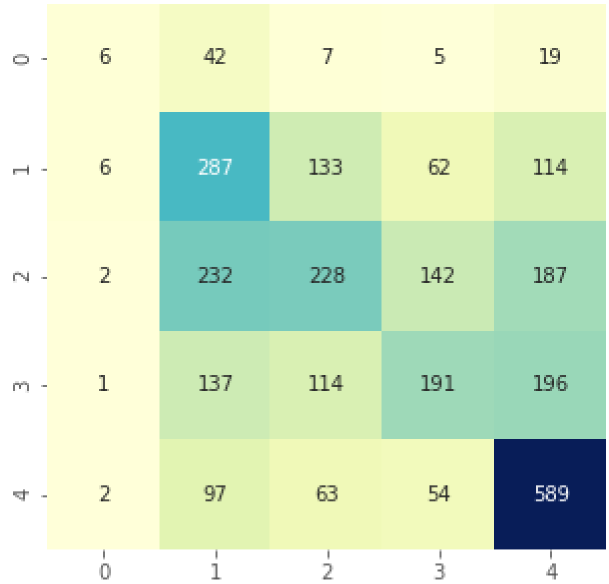
```
 Score = 0.4168135477070587
Time = 10.02495813369751 seconds
```



In [209]:

```
t_start = time.time()
r_forest = RandomForestClassifier(class_weight='balanced', max_depth=14,
                       min_samples_leaf=3, n_estimators=300, random_state=42)
r_forest.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, r_forest.predict(X_test_tar), weights='quad
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, r_forest.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.4166656016064654
Time = 8.586639642715454 seconds
```

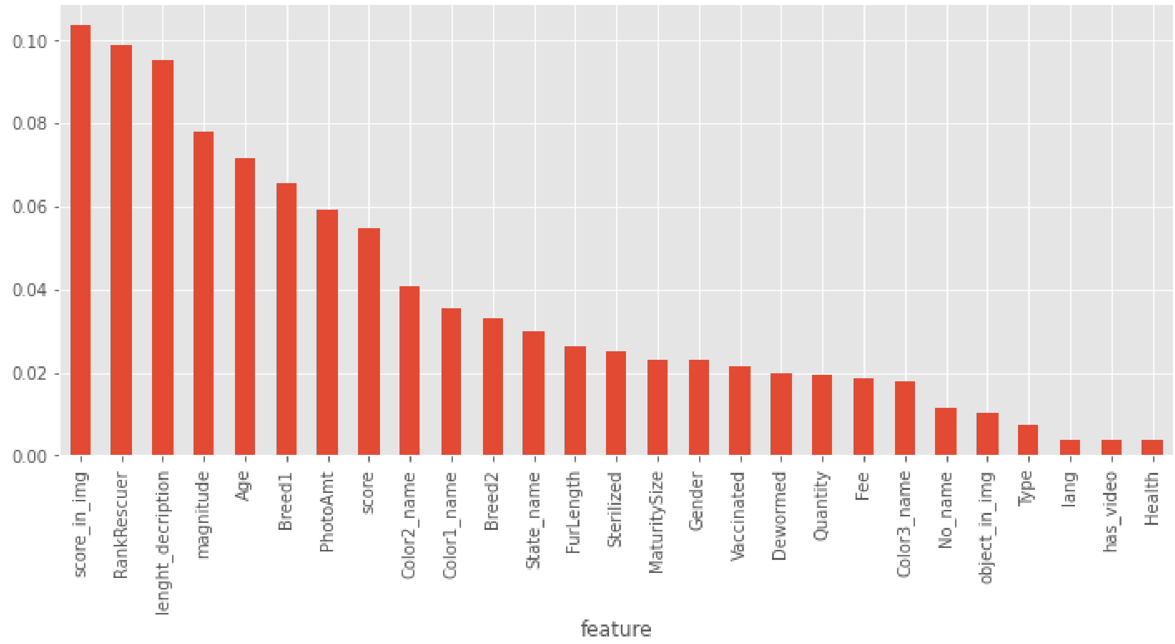


In [210]:

```
featureImportance = pd.DataFrame({"feature": X_train.columns,
                                  "importance": r_forest.feature_importances_})

# смотрим, какие признаки влияют на то, что модель предскажет 0 класс

featureImportance.set_index('feature', inplace=True)
featureImportance.sort_values(["importance"], ascending=False, inplace=True)
featureImportance["importance"].head(30).plot(kind='bar', figsize=(12,5))
featureImportance["importance"].tail(30).plot(kind='bar', figsize=(12,5))
```

Out[210]:

```
<AxesSubplot:xlabel='feature'>
```



Бустинг

Адаптивный бустинг

In [182]:

```
ada_clf = AdaBoostClassifier()
ada_clf.fit(X_train, y_train)

print(cohen_kappa_score(y_test, ada_clf.predict(X_test), weights='quadratic'))
```

```
0.34706331658842127
```

In [183]:

```
ada_clf = AdaBoostClassifier()
ada_clf.fit(X_train_ohe, y_train_ohe)

print(cohen_kappa_score(y_test_ohe, ada_clf.predict(X_test_ohe), weights='quadratic'))
```

```
0.3589410274110435
```

In [184]:

```
ada_clf = AdaBoostClassifier()
ada_clf.fit(X_train_tar, y_train_tar)

print(cohen_kappa_score(y_test_tar, ada_clf.predict(X_test_tar), weights='quadratic'))
```

```
0.3403528515979196
```

In [185]:

```
param_grid = {
    'n_estimators': [50, 100, 200, 300],
    'learning_rate': [1.0, 0.5, 0.25, 0.1],
    'algorithm': ['SAMME', 'SAMME.R']
}
ada_model = randomized_cv(AdaBoostClassifier(DecisionTreeClassifier(max_depth=7)), param_gr
```

```
Fitting 10 folds for each of 32 candidates, totalling 320 fits
[CV 1/10; 1/32] START algorithm=SAMME, learning_rate=1.0, n_estimators=5
0.......

C:\Users\Irina\Anaconda3\lib\site-packages\sklearn\model_selection\_searc
h.py:289: UserWarning: The total space of parameters 32 is smaller than n_
iter=40. Running 32 iterations. For exhaustive searches, use GridSearchCV.
  % (grid_size, self.n_iter, grid_size), UserWarning)
```

In [186]:

```
ada_model = randomized_cv(AdaBoostClassifier(DecisionTreeClassifier(max_depth=7)), param_gr
```

```
Fitting 10 folds for each of 32 candidates, totalling 320 fits
[CV 1/10; 1/32] START algorithm=SAMME, learning_rate=1.0, n_estimators=5
0.......

C:\Users\Irina\Anaconda3\lib\site-packages\sklearn\model_selection\_searc
h.py:289: UserWarning: The total space of parameters 32 is smaller than n_
iter=40. Running 32 iterations. For exhaustive searches, use GridSearchCV.
  % (grid_size, self.n_iter, grid_size), UserWarning)
```

In [187]:

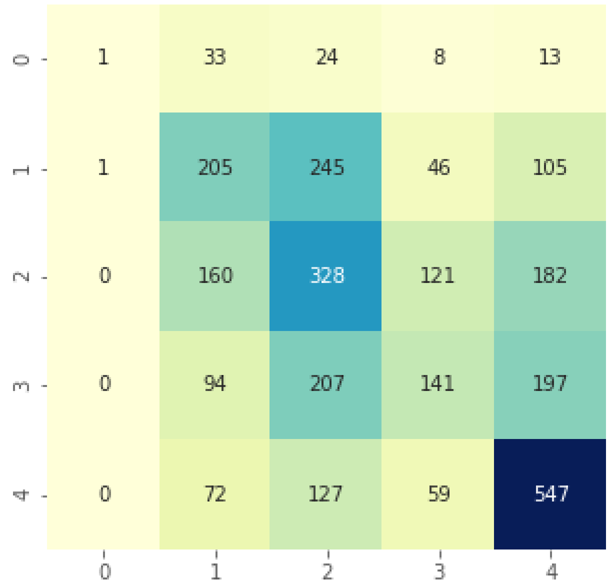
```
ada_model = randomized_cv(AdaBoostClassifier(DecisionTreeClassifier(max_depth=7)), param_gr
```

```
Fitting 10 folds for each of 32 candidates, totalling 320 fits
[CV 1/10; 1/32] START algorithm=SAMME, learning_rate=1.0, n_estimators=5
0.......

C:\Users\Irina\Anaconda3\lib\site-packages\sklearn\model_selection\_searc
h.py:289: UserWarning: The total space of parameters 32 is smaller than n_
iter=40. Running 32 iterations. For exhaustive searches, use GridSearchCV.
  % (grid_size, self.n_iter, grid_size), UserWarning)
```

In [211]:

```
t_start = time.time()
ada = AdaBoostClassifier(algorithm='SAMME',
                         base_estimator=DecisionTreeClassifier(max_depth=7),
                         learning_rate=0.1, n_estimators=100)
ada.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, ada.predict(X_test), weights='quadratic')}")
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, ada.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

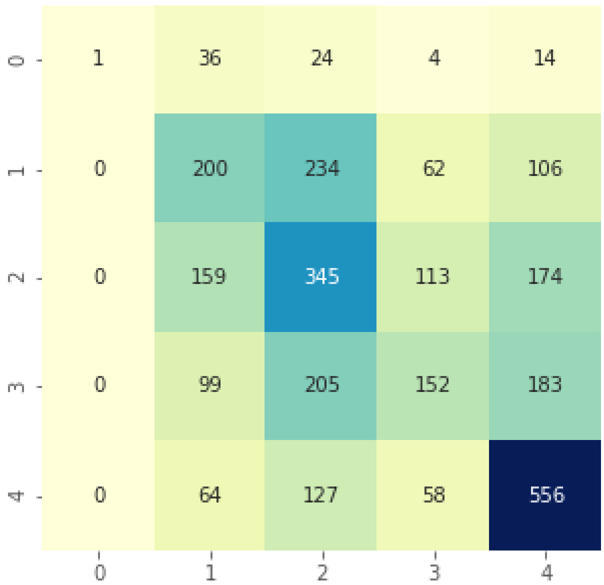
```
 Score = 0.398848056132398 27
Time = 10.266168117523193 seconds
```



In [212]:

```
t_start = time.time()
ada = AdaBoostClassifier(algorithm='SAMME',
                   base_estimator=DecisionTreeClassifier(max_depth=7),
                   learning_rate=0.1, n_estimators=100)
ada.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, ada.predict(X_test_ohe), weights='quadratic
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, ada.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

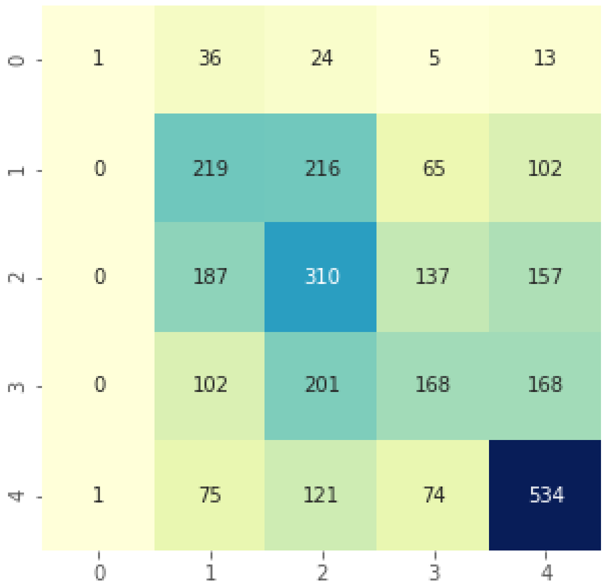
```
 Score = 0.40414212117212533
Time = 13.761859893798828 seconds
```



In [213]:

```
t_start = time.time()
ada = AdaBoostClassifier(algorithm='SAMME',
                   base_estimator=DecisionTreeClassifier(max_depth=7),
                   learning_rate=0.1, n_estimators=300)
ada.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, ada.predict(X_test_tar), weights='quadratic
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, ada.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.40067633933568349
Time = 30.173818826675415 seconds
```



Градиентный бустинг

In [188]:

```
est = GradientBoostingClassifier()
est.fit(X_train, y_train)

print(cohen_kappa_score(y_test, est.predict(X_test), weights='quadratic'))
```

```
0.3834166296276056
```

In [189]:

```
est = GradientBoostingClassifier()
est.fit(X_train_ohe, y_train_ohe)

print(cohen_kappa_score(y_test_ohe, est.predict(X_test_ohe), weights='quadratic'))
```

```
0.3932465272677671
```

In [190]:

```
est = GradientBoostingClassifier()
est.fit(X_train_tar, y_train_tar)

print(cohen_kappa_score(y_test_tar, est.predict(X_test_tar), weights='quadratic'))
```

```
0.39724209611651895
```

In [191]:

```
param_grid = {
    'n_estimators': [50, 100, 200, 300],
    'learning_rate': [1.0, 0.5, 0.25, 0.1],
    'criterion': ['friedman_mse', 'mse'],
    'max_depth': [1, 3, 5, 7]
}
gbc_model = randomized_cv(GradientBoostingClassifier(), param_grid, X_train, y_train, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=5, n_est
imators=200
[CV 1/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=5, n_estim
ators=200; total time=  42.9s
[CV 2/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=5, n_est
imators=200
[CV 2/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=5, n_estim
ators=200; total time=  43.1s
[CV 3/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=5, n_est
imators=200
[CV 3/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=5, n_estim
ators=200; total time=  43.8s
[CV 4/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=5, n_est
imators=200
[CV 4/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=5, n_estim
ators=200; total time=  43.8s
[CV 5/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=5, n_est
imators=200
```

In [192]:

```
gbc_model = randomized_cv(GradientBoostingClassifier(), param_grid, X_train_ohe, y_train_oh
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=7, n_est
imators=300
[CV 1/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=7, n_estim
ators=300; total time= 2.3min
[CV 2/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=7, n_est
imators=300
[CV 2/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=7, n_estim
ators=300; total time= 2.4min
[CV 3/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=7, n_est
imators=300
[CV 3/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=7, n_estim
ators=300; total time= 2.4min
[CV 4/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=7, n_est
imators=300
[CV 4/10; 1/30] END criterion=mse, learning_rate=1.0, max_depth=7, n_estim
ators=300; total time= 2.5min
[CV 5/10; 1/30] START criterion=mse, learning_rate=1.0, max_depth=7, n_est
imators=300
```

In [193]:

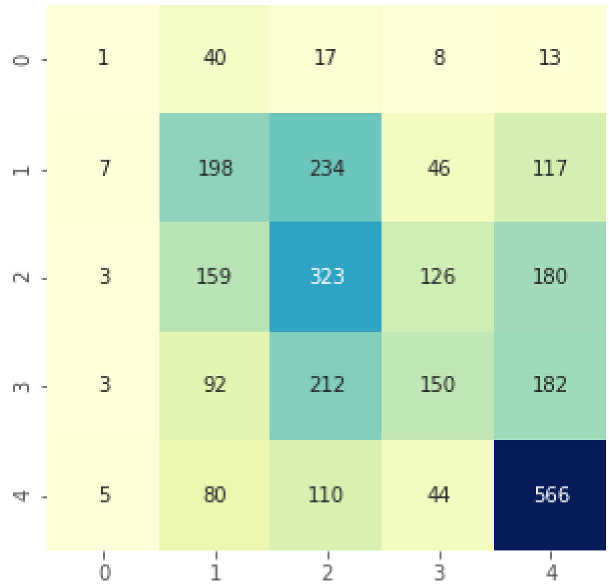
```
gbc_model = randomized_cv(GradientBoostingClassifier(), param_grid, X_train_tar, y_train_ta
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START criterion=friedman_mse, learning_rate=0.25, max_dept
h=5, n_estimators=50
[CV 1/10; 1/30] END criterion=friedman_mse, learning_rate=0.25, max_depth=
5, n_estimators=50; total time=   9.7s
[CV 2/10; 1/30] START criterion=friedman_mse, learning_rate=0.25, max_dept
h=5, n_estimators=50
[CV 2/10; 1/30] END criterion=friedman_mse, learning_rate=0.25, max_depth=
5, n_estimators=50; total time=   9.7s
[CV 3/10; 1/30] START criterion=friedman_mse, learning_rate=0.25, max_dept
h=5, n_estimators=50
[CV 3/10; 1/30] END criterion=friedman_mse, learning_rate=0.25, max_depth=
5, n_estimators=50; total time=   9.7s
[CV 4/10; 1/30] START criterion=friedman_mse, learning_rate=0.25, max_dept
h=5, n_estimators=50
[CV 4/10; 1/30] END criterion=friedman_mse, learning_rate=0.25, max_depth=
5, n_estimators=50; total time=   9.8s
[CV 5/10; 1/30] START criterion=friedman_mse, learning_rate=0.25, max_dept
h=5, n_estimators=50
```

In [214]:

```
t_start = time.time()
gbc = GradientBoostingClassifier(n_estimators=200)
gbc.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, gbc.predict(X_test), weights='quadratic')}")
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, gbc.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

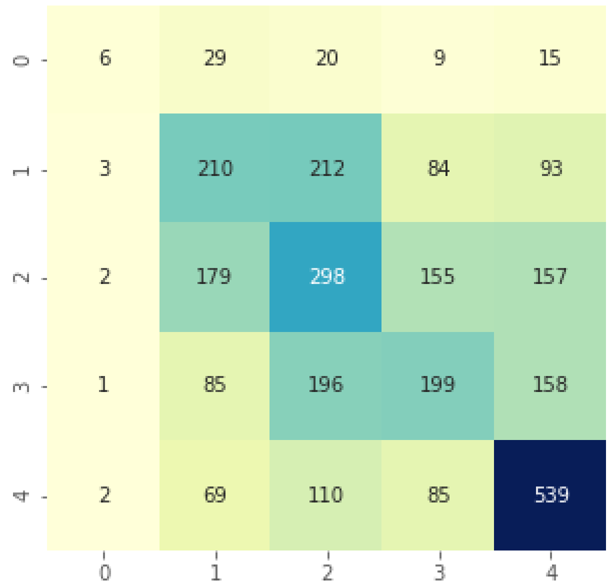
```
 Score = 0.388522858987409 46
Time = 41.428433895111084 seconds
```



In [215]:

```
t_start = time.time()
gbc = GradientBoostingClassifier(max_depth=7, n_estimators=300)
gbc.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, gbc.predict(X_test_ohe), weights='quadratic
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, gbc.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

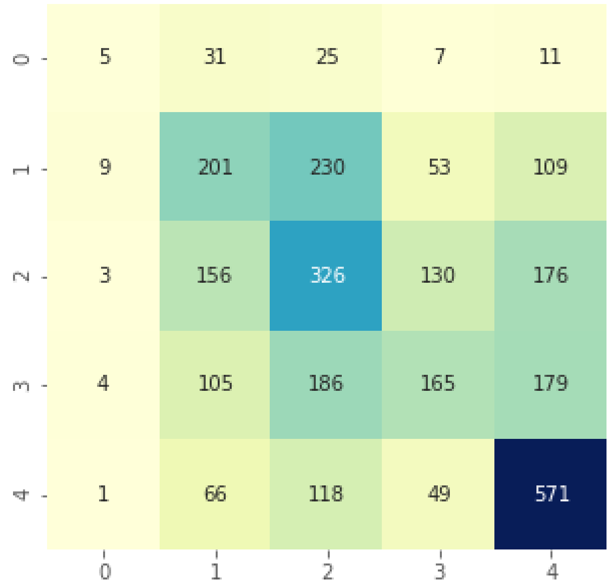
```
 Score = 0.40820360279879561
Time = 179.62291812896729 seconds
```



In [216]:

```
t_start = time.time()
gbc = GradientBoostingClassifier(max_depth=5)
gbc.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, gbc.predict(X_test_tar), weights='quadratic
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, gbc.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.41129513918161065
Time = 31.47444725036621 seconds
```



XGB

In [217]:

```
xgb_model = xgb.XGBClassifier()
xgb_model.fit(X_train, y_train)

print(cohen_kappa_score(y_test, xgb_model.predict(X_test), weights='quadratic'))
```

```
0.4175859196649011
```

In [218]:

```
xgb_model = xgb.XGBClassifier()
xgb_model.fit(X_train_ohe, y_train_ohe)

print(cohen_kappa_score(y_test_ohe, xgb_model.predict(X_test_ohe), weights='quadratic'))
```

```
0.41794548529289366
```

In [219]:

```
xgb_model = xgb.XGBClassifier()
xgb_model.fit(X_train_tar, y_train_tar)

print(cohen_kappa_score(y_test_tar, xgb_model.predict(X_test_tar), weights='quadratic'))
```

```
0.4231012369500242
```

In [220]:

```
param_grid = {
    'max_depth': [1, 3, 5, 7, 9],
    'n_estimators': [50, 100, 200, 300],
    'learning_rate': [1.0, 0.5, 0.1, 0.05, 0.025, 0.01, 0.005]
}
```

In [221]:

```
xgb = randomized_cv(xgb.XGBClassifier(), param_grid, X_train, y_train, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START learning_rate=0.025, max_depth=9, n_estimators=30
0........
[CV 1/10; 1/30] END learning_rate=0.025, max_depth=9, n_estimators=300; to
tal time= 1.2min
[CV 2/10; 1/30] START learning_rate=0.025, max_depth=9, n_estimators=30
0........
[CV 2/10; 1/30] END learning_rate=0.025, max_depth=9, n_estimators=300; to
tal time= 1.1min
[CV 3/10; 1/30] START learning_rate=0.025, max_depth=9, n_estimators=30
0........
[CV 3/10; 1/30] END learning_rate=0.025, max_depth=9, n_estimators=300; to
tal time= 1.1min
[CV 4/10; 1/30] START learning_rate=0.025, max_depth=9, n_estimators=30
0........
[CV 4/10; 1/30] END learning_rate=0.025, max_depth=9, n_estimators=300; to
tal time= 1.0min
[CV 5/10; 1/30] START learning_rate=0.025, max_depth=9, n_estimators=30
0........
```

In [225]:

```
xgb = randomized_cv(XGBClassifier(), param_grid, X_train_ohe, y_train_ohe, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START learning_rate=0.1, max_depth=9, n_estimators=10
0..........
[CV 1/10; 1/30] END learning_rate=0.1, max_depth=9, n_estimators=100; tota
l time=  21.3s
[CV 2/10; 1/30] START learning_rate=0.1, max_depth=9, n_estimators=10
0..........
[CV 2/10; 1/30] END learning_rate=0.1, max_depth=9, n_estimators=100; tota
l time=  19.5s
[CV 3/10; 1/30] START learning_rate=0.1, max_depth=9, n_estimators=10
0..........
[CV 3/10; 1/30] END learning_rate=0.1, max_depth=9, n_estimators=100; tota
l time=  18.6s
[CV 4/10; 1/30] START learning_rate=0.1, max_depth=9, n_estimators=10
0..........
[CV 4/10; 1/30] END learning_rate=0.1, max_depth=9, n_estimators=100; tota
l time=  17.9s
[CV 5/10; 1/30] START learning_rate=0.1, max_depth=9, n_estimators=10
0..........
```

In [226]:

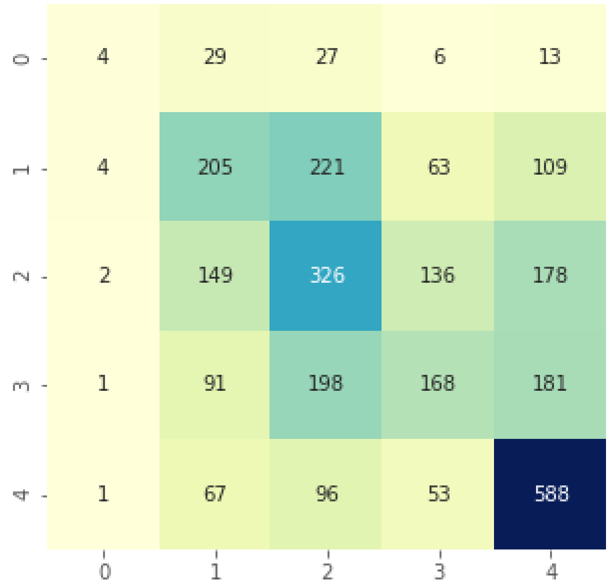
```
xgb = randomized_cv(XGBClassifier(), param_grid, X_train_tar, y_train_tar, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START learning_rate=0.005, max_depth=7, n_estimators=5
0.........
[CV 1/10; 1/30] END learning_rate=0.005, max_depth=7, n_estimators=50; tot
al time=   4.5s
[CV 2/10; 1/30] START learning_rate=0.005, max_depth=7, n_estimators=5
0.........
[CV 2/10; 1/30] END learning_rate=0.005, max_depth=7, n_estimators=50; tot
al time=   4.5s
[CV 3/10; 1/30] START learning_rate=0.005, max_depth=7, n_estimators=5
0.........
[CV 3/10; 1/30] END learning_rate=0.005, max_depth=7, n_estimators=50; tot
al time=   4.5s
[CV 4/10; 1/30] START learning_rate=0.005, max_depth=7, n_estimators=5
0.........
[CV 4/10; 1/30] END learning_rate=0.005, max_depth=7, n_estimators=50; tot
al time=   4.4s
[CV 5/10; 1/30] START learning_rate=0.005, max_depth=7, n_estimators=5
0.........
```

In [228]:

```
t_start = time.time()
xgb = XGBClassifier(learning_rate=0.025, max_depth=9, n_estimators=300)
xgb.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, xgb.predict(X_test), weights='quadratic')}")
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, xgb.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

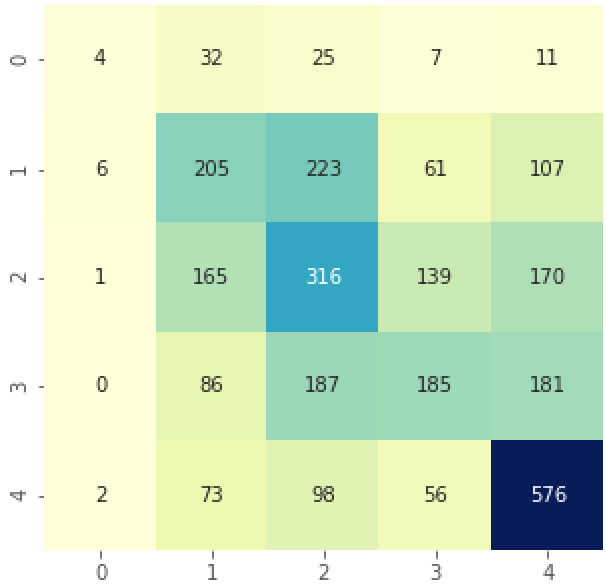
```
 Score = 0.4181770886538607
Time = 46.994672536849976 seconds
```



In [229]:

```
t_start = time.time()
xgb = XGBClassifier(base_score=0.5, booster='gbtree', learning_rate=0.025, max_depth=9, n_e
xgb.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, xgb.predict(X_test_ohe), weights='quadratic
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, xgb.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

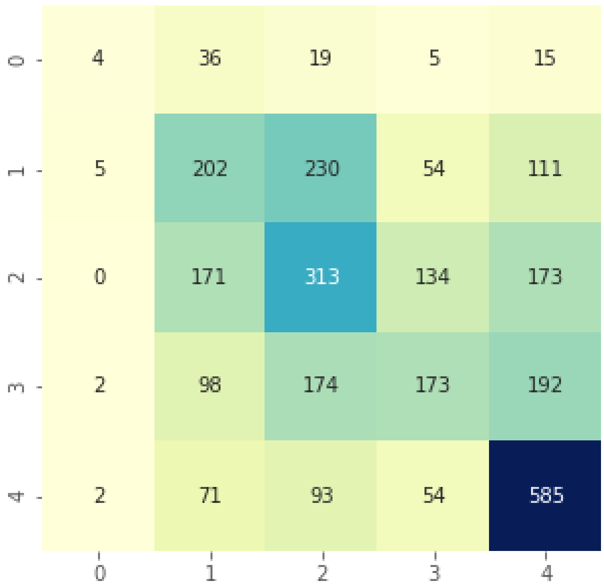
```
 Score = 0.4213457502881114
Time = 52.873796463012695 seconds
```



In [230]:

```
t_start = time.time()
xgb = XGBClassifier(base_score=0.5, booster='gbtree', learning_rate=0.1, max_depth=9, n_est
xgb.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, xgb.predict(X_test_tar), weights='quadratic
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, xgb.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
 Score = 0.4191713864260447
Time = 8.319628953933716 seconds
```



LightGBM

In [233]:

```
lgb_model = lgb.LGBMClassifier()
lgb_model.fit(X_train, y_train)

print(cohen_kappa_score(y_test, lgb_model.predict(X_test), weights='quadratic'))
```

```
0.42737008915551244
```

In [234]:

```
lgb_model = lgb.LGBMClassifier()
lgb_model.fit(X_train_ohe, y_train_ohe)

print(cohen_kappa_score(y_test_ohe, lgb_model.predict(X_test_ohe), weights='quadratic'))
```

```
0.4192884742700542
```

In [235]:

```
lgb_model = lgb.LGBMClassifier()
lgb_model.fit(X_train_tar, y_train_tar)

print(cohen_kappa_score(y_test_tar, lgb_model.predict(X_test_tar), weights='quadratic'))
```

```
0.43022984971564404
```

In [236]:

```
param_grid = {
    'max_depth': [1, 3, 5, 7, 9],
    'n_estimators': [50, 100, 200, 300],
    'learning_rate': [1.0, 0.5, 0.1, 0.05, 0.025, 0.01, 0.005]
}
```

In [237]:

```
lgb_model = randomized_cv(lgb.LGBMClassifier(), param_grid, X_train, y_train, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START learning_rate=0.5, max_depth=9, n_estimators=5
0...........
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves a
nd 2^max_depth > num_leaves
[CV 1/10; 1/30] END learning_rate=0.5, max_depth=9, n_estimators=50; total
time=   1.3s
[CV 2/10; 1/30] START learning_rate=0.5, max_depth=9, n_estimators=5
0...........
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves a
nd 2^max_depth > num_leaves
[CV 2/10; 1/30] END learning_rate=0.5, max_depth=9, n_estimators=50; total
time=   1.5s
[CV 3/10; 1/30] START learning_rate=0.5, max_depth=9, n_estimators=5
0...........
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves a
nd 2^max_depth > num_leaves
[CV 3/10; 1/30] END learning_rate=0.5, max_depth=9, n_estimators=50; total
time=   1.5s
[CV 4/10; 1/30] START learning_rate=0.5, max_depth=9, n_estimators=5
```

In [238]:

```
lgb_model = randomized_cv(lgb.LGBMClassifier(), param_grid, X_train_ohe, y_train_ohe, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START learning_rate=0.01, max_depth=1, n_estimators=30
0.........
[CV 1/10; 1/30] END learning_rate=0.01, max_depth=1, n_estimators=300; tot
al time=   1.7s
[CV 2/10; 1/30] START learning_rate=0.01, max_depth=1, n_estimators=30
0.........
[CV 2/10; 1/30] END learning_rate=0.01, max_depth=1, n_estimators=300; tot
al time=   1.6s
[CV 3/10; 1/30] START learning_rate=0.01, max_depth=1, n_estimators=30
0.........
[CV 3/10; 1/30] END learning_rate=0.01, max_depth=1, n_estimators=300; tot
al time=   1.6s
[CV 4/10; 1/30] START learning_rate=0.01, max_depth=1, n_estimators=30
0.........
[CV 4/10; 1/30] END learning_rate=0.01, max_depth=1, n_estimators=300; tot
al time=   1.6s
[CV 5/10; 1/30] START learning_rate=0.01, max_depth=1, n_estimators=30
0.........
```

In [239]:

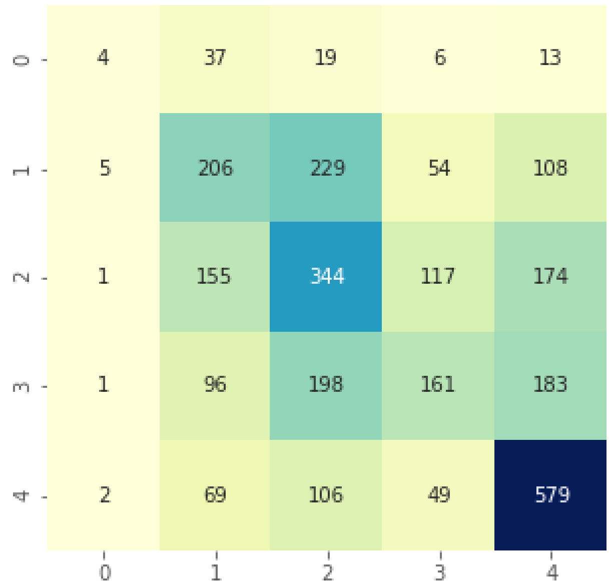
```
lgb_model = randomized_cv(lgb.LGBMClassifier(), param_grid, X_train_tar, y_train_tar, 30)
```

```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
[CV 1/10; 1/30] START learning_rate=0.1, max_depth=5, n_estimators=20
0..........
[CV 1/10; 1/30] END learning_rate=0.1, max_depth=5, n_estimators=200; tota
l time=   2.9s
[CV 2/10; 1/30] START learning_rate=0.1, max_depth=5, n_estimators=20
0..........
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves a
nd 2^max_depth > num_leaves
[CV 2/10; 1/30] END learning_rate=0.1, max_depth=5, n_estimators=200; tota
l time=   2.9s
[CV 3/10; 1/30] START learning_rate=0.1, max_depth=5, n_estimators=20
0..........
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves a
nd 2^max_depth > num_leaves
[CV 3/10; 1/30] END learning_rate=0.1, max_depth=5, n_estimators=200; tota
l time=   3.1s
[CV 4/10; 1/30] START learning_rate=0.1, max_depth=5, n_estimators=20
0..........
```

In [240]:

```
t_start = time.time()
lgb_model = lgb.LGBMClassifier(learning_rate=0.05, max_depth=9, n_estimators=200)
lgb_model.fit(X_train, y_train)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test, lgb_model.predict(X_test), weights='quadratic')
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test, lgb_model.predict(X_test))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

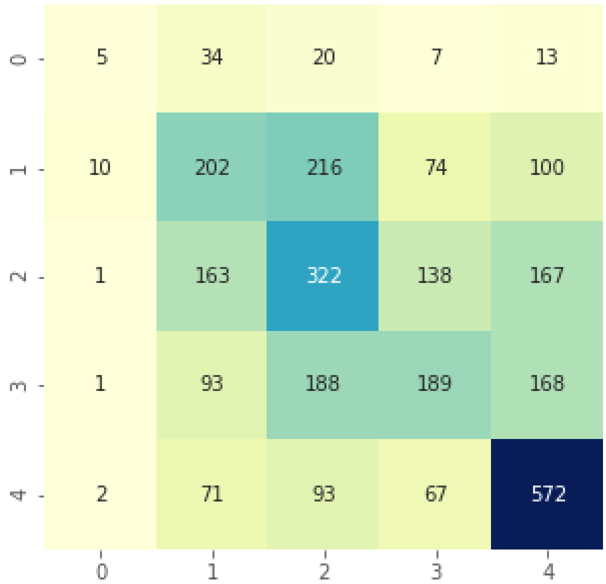
```
 Score = 0.42031303461617664
Time = 3.1988062858581543 seconds
```



In [241]:

```
t_start = time.time()
lgb_model = lgb.LGBMClassifier(max_depth=7, n_estimators=200)
lgb_model.fit(X_train_ohe, y_train_ohe)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_ohe, lgb_model.predict(X_test_ohe), weights='qua
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_ohe, lgb_model.predict(X_test_ohe))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

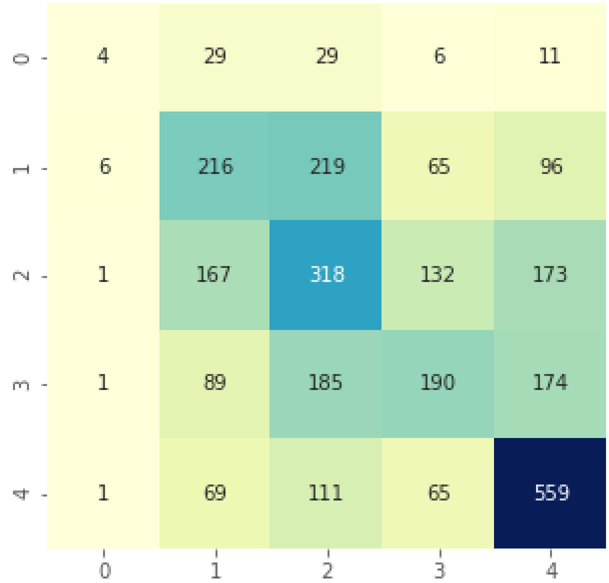
```
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves and
2^max_depth > num_leaves
 Score = 0.4228013688152027
Time = 3.471630811691284 seconds
```



In [242]:

```
t_start = time.time()
lgb_model = lgb.LGBMClassifier(max_depth=9, n_estimators=200)
lgb_model.fit(X_train_tar, y_train_tar)
t_end = time.time()

print(f" Score = {cohen_kappa_score(y_test_tar, lgb_model.predict(X_test_tar), weights='qua
print(f"Time = {t_end - t_start} seconds")

cm = confusion_matrix(y_test_tar, lgb_model.predict(X_test_tar))
conf_matrix = pd.DataFrame(data = cm, index=range(0, 5), columns=range(0, 5))
plt.figure(figsize = (5,5))
sns.heatmap(conf_matrix, annot=True,fmt='d',cmap="YlGnBu", cbar=False);
```

```
[LightGBM] [Warning] Accuracy may be bad since you didn't set num_leaves and
2^max_depth > num_leaves
 Score = 0.4249991191199106
Time = 3.408841609954834 seconds
```



In [ ]: